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ASSOCIATE ADMINISTRATOR FOR COMMERCIAL SPACE TRANSPORTATION
(AST)

SEVENTH ANNUAL COMMERCIAL SPACE TRANSPORTATION FORECAST CONFERENCE

WEDNESDAY,
FEBRUARY 11, 2004

The conference was held at 8:00 a.m. in Ballroom II of the Fairmont Hotel, 2401 M Street, NW, Washington, D.C., Patricia Grace Smith, Associate Administrator for Commercial Space Transportation, presiding.

PRESENT:

JEFF GREASON
JAMES R. HEALD
JOAN C. HORVATH
TIM HUDDLESTON
EDWARD L. HUDGINS
AL KOLLER
LESLIE J. KOVACS
GREGG MARYNIAK
CAREY McCLESKY
ELON MUSK
JEFF SPAULDING
TROY THRASH
JOHN VINTER

PRESENT FROM FAA/AST:

PATRICIA GRACE SMITH
STEWART JACKSON
CHUCK LARSEN
CAMILLA McARTHUR
MICHELLE MURRAY
GEORGE C. NIELD
KEN WONG

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PROCEEDINGS

(8:07 a.m.)

MS. McARTHUR: Good morning everyone, and welcome to the second day of the Seventh Annual Commercial Space Transportation Conference and our 20th anniversary celebration. Before we begin the conference, I want to repeat a few housekeeping notes for you, and then I'll introduce our guests.

First of all, again, we'd like to emphasize that we do have the evaluation forms, and we do utilize those in reviewing how we're doing in the conference and determining some of the things that we will be doing in future conferences. Your point of view is very important, and we would appreciate it if you would fill those out and leave those with the people at the receptionist's desk.

The second thing is the tour sign-up. If you are planning to go on the tour, then please sign up on the sheet outside so that we can make sure that we have a count. We're going to be leaving on time, so today we're going to run the schedule hopefully promptly and on time.

As far as the program books are concerned, we are aware that some of you didn't get them. If you would leave your names and addresses with the people at the registration desk, we'll be more than happy to mail you some as soon as we get them printed which will be in short order.

Lastly the Launch Site Applicants Workshop is tomorrow in the Bessie Coleman Center at FAA Headquarters at 9:00 a.m., and we look forward to seeing you there as well.

Now, I'd like to begin today's program. We're honored to have with us Mr. John Vinter. Mr. Vinter is the President and CEO of International Space Brokers, Incorporated. He has been involved with virtually all aspects of satellite businesses for over 30 years. Mr. Vinter was appointed to the Department of Transportation's Commercial Space Transportation Advisory Committee, COMSTAC, in January of 2000 by former Secretary of Transportation, Rodney Slater. He has served as the Chairperson of COMSTAC's Risk Management Working Group and as the Deputy Chair of the full committee.

In July 2003, he was appointed as the COMSTAC Chairperson by our current Administrator, Marion Blakey, and he assumed the official duties of the Chairperson at the October 2003 COMSTAC meeting. Mr. Vinter founded ISB in February of 1991 in conjunction with three permanent insurance brokerage organizations. Since its founding, ISB has consistently maintained a 30- to 40-percent market share. Before founding ISB, Mr. Vinter was the Executive Vice President in charge of space underwriting at INTEC, now AXA Space.

He has held a variety of positions with Satellite Business Systems, negotiating a contract for the first HS-0376 satellite as well as the first commercial shuttle launch services agreement with NASA. Mr. Vinter has also managed the procurement of major satellite and ground system components for Comsat Corporation. He has an AA degree in Economics from Georgetown University and an MS degree in Telecommunications Operations from George Washington University.

Ladies and gentlemen, it is my pleasure to introduce the COMSTAC Chairperson, Mr. John Vinter.

(Applause)

MR. VINTER: Good morning and thank you, Camilla. I'm honored to be here this morning to introduce the featured speaker for the final day of the Seventh Annual Commercial Space Transportation Conference, Mr. Elon Musk. Elon Musk is the CEO and Chief Technology Officer for Space Exploration Technologies, better known as SpaceX, which is located in El Segundo, California.

As you can see, he looks very young and the reason is he is very young. However, that doesn't change the fact that SpaceX is already his third business venture. Prior to SpaceX, he co-founded PayPal, the world's leading electronic payment system, and served as the company's chairman and CEO. PayPal has over 20 million customers in 38 countries, processes several billion dollars per year, and went public on the NASDAQ in early 2002. Mr. Musk was the largest shareholder of PayPal until the company was acquired by eBay for $1.5 billion in October of '02.

Before PayPal, Mr. Musk co-founded Zip2 Corporation in '95, a leading provider of Enterprise software and services to the media industry, where he also served as chairman, CEO, and chief technology officer. Most of us have read about Elon in business journals, on the Internet, and in the news over the past few years. Most recently on December 4th, 2003, he was in the news because of the unveiling and display of the Falcon rocket in front of the FAA's office building.

The Falcon is the company's first product, and the entire seven-story high vehicle and its mobile launch system were brought to the Capitol by way of flatbed tractor-trailer as part of the nation's Centennial of Flight celebration. Patti was there with him for the official unveiling.

Elon's early experience extends across a spectrum of advanced technology industries from high-energy density ultra-capacitors at Pinnacle Research to software development of rocket science and Microsoft. He has a physics degree from the University of Pennsylvania, a business degree from Wharton, and originally came out to California to pursue graduate studies in energy physics at Stanford. So I'll now present to you Mr. Elon Musk. Elon?

(Applause.)

MR. MUSK: Thanks for coming here and listening to me. Well, let's see, I guess as you can see, I'm rather young but I was born at a young age, so -- anyway what I want to talk about today is just the SpaceX approach to improving the cost and reliability of access to space. And let me sort of start it by saying how did I get into this game because that's what people are usually wondering. How did you go from doing some Internet- related thing to space, not an obvious transition? And actually, that reminds me of something.

I heard the joke so many times, you know, how do you make a small fortune in space, you start with a large one. But I started pre-empting people. They'd say, why did you start a space company, and I'd say, well, I had a large fortune and I was trying to figure out how to get it small. Space seemed the obvious choice. But let me sort of go into exactly what led me here. I've always been interested in space, I think since I was a kid. And not in the sense of I wanted to be an astronaut.. I didn't really have astronaut aspirations, but I always thought that space was a very interesting arena. It's almost trite to say, but I think that's where humanity's future lies.

And in that context and in the context of the science fiction books written by Asimov or Heinlein, or any of those sort of great books and movies in the Sci-Fi genre, I think it's just a really fascinating arena. When it became clear that PayPal was going to go public, and I was winding down my active role in the company, I was trying to figure out what to do next. In talking with a friend of mine, I said, "You know, I always thought space was really interesting" but I didn't think there was anything one could really do to move the ball forward in space. We got to talking and I thought, well, maybe there's something from a philanthropic standpoint that can be done, and we came up with this idea for a small robotic Mars mission called Mars Oasis.

This was, obviously, some years ago, prior to the President [George W. Bush] announcing that Mars would be our objective. The goal of the Mars Oasis project would have been to get the President to say that Mars was our objective, so it's a good thing we didn't do that. In any event, it did lead me to this place, which is good, in that we priced out fully the cost of doing a small robotic Mars mission. The idea behind it would have been to put a small lander on the surface of Mars with seeds in dehydrated nutrient gel that would hydrate upon landing, and you'd have a small, about a three-foot across greenhouse with plants growing in an Earth-ambient environment. It would have some precedents and superlatives; that's what the public tends to respond to. It would be the first lives ever traveled, first life on Mars. You'd have this great shot of Earth plants growing against a Martian background. That's what we thought would get the public excited.

We priced out everything: time on the Deep Space Network, all the components and labor necessary to do the spacecraft and the experiment. We did everything. Then we came to the question of launch, and that's where you sort of run out of options. If you look at the U.S. possibilities, you really need a Delta 2 which is something on the order of $60 to $70 million, depending on who you ask. That's a lot of philanthropy, so I looked at a couple other options.

I went to Russia three times, met with various organizations over there, most notably Kosmotras which has the Dneiper or SS-18 and looked at that as an option and got a substantially better price out of them, but there were a lot of complications. It sort of stands to reason that if you're trying to buy a refurbished ICBM, launch it in an Islamic republic, and you're an American company, there are complications associated with that.

(Laughter)

Not that it couldn't be done. I think it probably could, but when you add on the fact that you're talking about, in that particular case, a Mars mission where you've got a 30-day window every 26 months, that really makes things dodgy. If you miss that window, you're in deep trouble. Anyway, coming back from the third trip to Russia, it occurred to me:, “Why is it that the Russians have lower cost launch vehicles than the U.S.?” It's not as though the Russians are competitive in other spheres. We don't drive their cars, fly their planes, or use their kitchen appliances. In fact, when is the last time you used a Russian product that wasn't vodka? I think that fundamentally U.S. is a very competitive place, and the anomaly is not that the Russians are so good. It's more we are really -- we've really dropped the ball, I think, here in the U.S. on launch. The fact of the matter is, we're not competitive worldwide in the launch market. If national competition were allowed in the U.S., Boeing and Lockheed would be out of the launch business.

It is only the support of the U.S. Government that keeps them in it. So, coming back from that third trip, I put together a feasibility study group consisting of engineers that have been involved with all major launch vehicle developments over the past three decades. They've been part of Delta 2, 3 and 4; Atlas II, III and V; Taurus; Pegasus; and so forth and also had some familiarity with the way the Russians did things. We met over a series of Saturdays because some of them were still working. The question to the group was, "Can we do this in the U.S. with the U.S. labor rates?" We can't just build a low-cost launch vehicle. It has to be a more reliable launch vehicle as well. In fact, reliability is a more important driver than cost.

If you've got something blowing up 3 percent of the time, that's completely unacceptable. Ultimately the conclusion of that group was that we could make improvements on both cost and reliability. Once I reached the critical mass in my mind, I decided to bite the bullet and start SpaceX and that was in June of 2002. It's been about 20 or so months since then. Let me go through some of the progress we've made over that time frame.

The starting launch vehicle, our initial product, is Falcon 1, and Falcon 1 is a light class launch vehicle. The reason for this strategy of going for a light class launch vehicle is that we wanted to have something we could wrap our arms around, which you can almost do. If you had two people, you could wrap your arms around the fuselage. It's about a five and a half foot diameter vehicle and about 70 feet long. I wanted something that we could execute on fairly fast, and that if there was a problem, we had sufficient capital to keep going. I think that's very important. In studying prior launch vehicle efforts, it's a pretty big graveyard for those of you who are familiar with the history of entrepreneurial space. It's not a very pleasant one.

You know, it's a big graveyard, and there probably are some freshly dug pits waiting to be filled. We don't want to fill them. I wanted to make sure that the strategy that we pursued allowed for failure. Within the financial war chest that we have available to ourselves, we can absorb failure. We can lose a rocket on the first launch. We can lose a second launch. I think if we lose three in a row, we don't know what we're doing; we should get out of the business. But it's not going to be a case of we'll get to the launch pad, there's an explosion, and it's game over. Absolutely not. We're going to keep going.

In fact, we're building two complete launch vehicles right off the bat, so there will be two vehicles ready to go. We've actually been able to sell our first launch. Our first launch is a DOD payload built by the NRL. It's called TACSAT 1. It's an experimental communications satellite. We should launch that around the middle of this year although the timing of that is very much driven by when we feel we've achieved a sufficient reliability threshold. We are, I guess the phrase is event driven, not date driven.

The notable thing here is the Falcon 1 is selling for $6 million a flight. That's an all-inclusive price with the exception of range fees which vary by launch location. Range fees are anywhere from a half million dollars to perhaps, $900,000.00. That's something we're working to reduce. It's just a function of what the range charges us essentially.

So for a complete all-inclusive, under $7 million you're getting a 1500- pound orbital launcher.

I'll go into some of the technical details of the vehicle, so you have something in that regard. The picture you see there is the SpaceX factory in El Segundo, just about a mile south of LAX [Los Angeles International Airport]. Most people are quite astonished to hear that we're building rockets in LA. It does sound kind of strange.

You can see the vehicle on that sort of blue track–. That's a laser-aligned precision manufacturing track. This is about 20,000 square feet of factory space. We've just signed a lease on another 20,000 square feet adjacent to it, so we're about 50,000 square feet in total.

Here you can see the vehicle being picked up by two forklifts, one at the base and one at the forward end. The whole vehicle is only about 4,000 pounds without a satellite on board. So it weighs less than an SUV [Sport Utility Vehicle]. This is an unpressurized structure – no problem to pick up. There it's on the mobile launcher system, and we have kind of a Conestoga hoops and canvas approach to protecting against road debris. That's leaving the SpaceX factory on route to Washington, D.C. for the unveiling on December 4th.

Here we look at the actual design of the first-stage tank. It's a fairly unique design. I'm not aware of anything that's quite like this. We call it flight pressure stabilized which means that it relies on pressure. It relies very heavily on pressure stabilization in flight for structural rigidity, but on the ground it is stable enough to stand up under its own weight fully loaded with propellant in light wind conditions. Then it uses the strong back of the mobile erector to protect against strong wind conditions. As soon as it's pressurized, it can stand up in a hurricane.

The net result is that we get a very good mass ratio. For a small launch vehicle, this is really quite excellent. That mass ratio includes residual propellant. It also includes the parachute recovery system. This is a reusable first stage, so it comes in via parachute to a water landing. Then it's picked up from the ocean. The first flight will land about 500 miles off the coast of Baja.

Actually, by mass, the vehicle is about 80-percent reusable. The first stage constitutes about 80 percent of the dry mass of the vehicle. This is the engine, the main engine. I should point out that the entire vehicle is a ground-up development at SpaceX, so the main engine, turbo-pump, upstage engine, structure, avionics, guidance system, launch system -- all of it obviously draws upon a rich heritage of prior developments.

Thrust-wise, we're at about 72,000 pounds sea level. That's sort of like a Redstone, if you're familiar with that, although we get a much better specific impulse. In fact, we want to confirm these numbers during final testing. It appears that this will be the highest performing kerosene engine ever built in the U.S. and the highest performing hydrocarbon gas generator cycle engine ever built, so this is really a pretty good engine.

It uses the pintle injector geometry. That was the same injector geometry used for the lunar module descent engine, extremely high reliability. No real known cases of combustion instability which is something that often plagues rocket engine developments. The turbo-pump actually serves three functions. It obviously has the main function of pressurizing the propellant, allowing us to have a lightweight tank set–. We also gimbal the nozzle of the gas generator exhaust to provide roll control. The turbo-pump also serves as the high-pressure hydraulic power source for the thrust vector control system, so it's actually a three in one deal.

This is one of the early engine tests of the main engine. What you see in the background there is our facility in Texas. Our headquarters are in LA. We do have propulsion development and our structural testing at our facility in Texas, which is about a 300-acre facility. It's a former Navy missile test range and really very well set up. If you look at the flame carefully, you'll see it's a very bright flame, no black streaks, which means we're getting really good combustion efficiency.

Our upper stage is currently expendable. Our long-term plans call for making the upper stage reusable, but for the time being, this is expendable. The material of choice is aluminum lithium, which is a difficult material to work with. It's what's used in the carrier brush of the Shuttle external tank and is a challenge to weld but has tremendous strength-to-weight characteristics. And that allows us to get a 91 percent mass ratio even though this is a pressure fed stage -- which is quite good for a pressure fed stage. It's a slightly different configuration than the first stage engine that uses hydraulic motors for thrust vector control. It also has a helium attitude control system. So that's Kestrel. In this case, the chamber is a copper heat sink chamber which is used for tuning the injector. Another thing that is noteworthy about this is that it has dual redundant navigation and dual redundant flight computers, and this is not typically seen in small launch vehicles. Usually, it's only the larger vehicles, like an Ariane 5, that have dual redundancy. What we wanted to do is build an avionics suite that would be something we could take directly and transfer it to our larger vehicles down the road. We wouldn't need to develop a separate avionics suite, so essentially somebody who is buying into a Falcon 1 is getting a big avionics suite in a small vehicle.

A few notable improvements here, we also use an Ethernet bus for communication instead of running serial cables all over the place, and we use a real time version of UNIX as an operating system. We've got three main launch sites that we've set up. Our primary one, the one we expect to use the most, is probably the one at Vandenberg, that's Pad 3 West. We just recently got awarded our license for Pad 3 West. You can see it there on the right, and we're just beginning construction to improve the site although you really don't need much construction in the case of the Falcon. I'll show you how launch sequence works.

We have Reagan Test Site in the Marshall Islands for equatorial launches, and of course, Pad 46 at the Cape is an arrangement we have with the Florida Space Authority. I will show you a slightly different launch. This is, obviously, a very accelerated launch sequence in case anyone is wondering. This is to give you some basic idea of how things work. You can note at the beginning, the launch director actually has just about everything you need to launch the vehicle, umbilicals and so forth. You can actually launch from a flat concrete pad. You don't really need a launch range.

I mentioned earlier that the primary focus was reliability and not cost. Let me draw that out a little bit. I've read a lot of studies on launch vehicle failures. One of the best ones, I think, is done by Ishi Chang at Aerospace Corporation a few years ago which was an empirical analysis of launch vehicle failures from 1980 to 1999. When you look at that, there's truly no mystery why launch vehicles failed. The statistics are clear. Of U.S. launch vehicle failures, 50 percent during that period were due to engine failure. Another 30 percent were due to stage separation failure. Everything else was in the noise. If you want to make a huge improvement at the system level to launch vehicle reliability, you minimize the number of engines. You minimize the number of stage separation events. Then, you work on making sure that each engine is going to work and each stage separation event is going to work.

When you look at Falcon 1, and I'll talk about Falcon 5 in a moment, but Falcon 1 has the minimum number of engines and stages that you need to get to orbit realistically, which is that it has two stages and one engine per stage, and only one engine that is, in fact, started in the air, the upper stage engine. We also do a hold before release, so we start up the main engine, and we hold down until we get a second's worth of steady state in the engine. If any parameters are phenomenal, the engine computer actually shuts down the vehicle and de-tanks automatically. It's like a run-up procedure that you have. If any of you are familiar with planes, before you take off in a plane, you go on the runway, and your run the engines up to full throttle. You check temperature. You check oil pressure. You make sure everything is good before you release. You don't just go throttling down the runway if the oil pressure is going crazy, and your temperature is going nuts.

Yet a lot of rockets are like that, so we make sure that the first engine is running properly before we release. Then, because there are only two stages, there's only one stage separation event. In our case, we have dual redundant separation systems. In fact, not just dual redundancy, but there's wiring coming from the upper stage, wiring coming from the lower stage, and separate batteries, so even if a wire is cut and a battery is dead, the stages are going to separate.

The upper stage engine also has a niobium nozzle rather than a carbon-carbon nozzle. The reason we chose that is niobium is a metal. If there's an impact -- if the second stage nozzle ends up hitting the inter-stage on separation, even if it's quite a strong impact, it will just dent the nozzle. It's not going to crack it as it would with carbon-carbon. What we see is ablative engine cooling rather than regenerative engine cooling which means we're not going to suffer problems from cracks in the regen cooling jacket. That was something that caused failure in an Ariane flight last year. I think I mentioned earlier, we can't run out of hydraulic fluid because we use the pressurized RP from the turbo-pump as the working fluid. There was a spectacular Delta 3 failure that resulted from running out of hydraulic fluid. That failure mode is not possible on Falcon.

There are a number of other reliability enhancements that we've worked on. In terms of how we've achieved the cost improvements, this has really been designed from the ground up with just reliability and cost, no other complicating requirements, no need to operate in very cold weather. It's really a pure and simple design. Simplicity is really the key, I would say. With simplicity you get both reliability and cost improvements at the same time. We run a very efficient, low overhead corporate environment.

The same propellants on both stages, and it's really hard to get cheaper than LOX [liquid oxygen] and kerosene. I won't read off the list here, but it's worth noting that the price of a launch of $6 million makes no assumption for reusability. Actually, I think at this point we're quite confident that there will be some – that the reusable economics will work out. If that assumption proves to be true, we will lower the price from $6 million. Actually, I bet somebody dinner in their finest restaurant in D.C. that the price of Falcon 1 will decrease and not increase with time.

Actually, I wanted to include some slides about Falcon 5 because that's really I think going to end up being more important to our business than Falcon 1, although Falcon 1 is still a good rocket. Falcon 5 is a Delta 2 heavy class vehicle potentially with Delta 4 medium capabilities if you put an RL-10 upper stage on it. Falcon 5 just takes five of the Merlin engines that you just saw, puts them together on a single, wide-body version of the same tank structure you just saw, makes use of the same avionics and guidance system in Falcon 1, and in the first iteration, makes use of essentially a larger pressure fed upper stage, but they gain the same engines, the same upstage engines. Essentially, Falcon 5 is made from the same pieces that Falcon 1 is made of, just more of them.

We expect to do the first flight of Falcon 5 probably around the third quarter or early fourth quarter of next year. No more than about 18 months from now I would say is when we expect to have something that's Delta 2 heavy class. In the case of Falcon 5, we'll have the further benefit of engine-out capability. This will be the first time that you'll have true engine-out capability in a launch vehicle in the U.S. since Saturn 5. If you're familiar with the history of Saturn 5, there were two missions, I think, Apollo 8 and 13 that were saved because they had engine-out redundancy.

We're actually very excited about Falcon 5, and I think we'll be able to announce a customer for Falcon 5 in the next few months. Before the middle of the year, we'll be able to announce a customer for Falcon 5. And that's it. Are there any questions?

AUDIENCE MEMBER: You showed on the video an accelerated launch sequence. Have you given any thought to rapid launch because obviously there's a need for it in DOD, and I guess sort of a follow-up question, obviously, if you're successful, there's opportunity to capture markets here from EELV and the like. What are your plans in terms of looking at the greater market?

MR. MUSK: Well, I think in terms of responsive launch, I can say both Falcon 1 and Falcon 5 will be a great deal more responsive than anything that's out there today. There are different gradients of responsiveness. I mean, for some people responsiveness is can you launch in the next hour, and for some it's can you launch in the next three months. Currently we ask for at least 8 months from contract signing to launch. When compared with, say, with most launch vehicle payloads which are typically on the order of two years, we're talking about a three-fold improvement in schedule on that front. If the vehicle is bought, the satellite or whatever payload is manifested, and it's ready to go and just sitting there on the mobile launcher, there's no reason we can't improve the time to launch to be equivalent to that of an Atlas II ICBM. You could launch in less than 10 minutes.

Atlas, I think, was 8 minutes to full launch, and it's a much bigger vehicle than Falcon 1 and uses the same propellants. I think you could go anywhere from ICBM speed to launch if you really wanted to or just as a matter of course, we will be three times faster than anyone else with no additional payments.

AUDIENCE MEMBER: What about market share?

MR. MUSK: Oh, yes, market share, sorry. We expect to compete vigorously, in the light, medium, heavy, and super heavy launch markets progressively. Yes.

AUDIENCE MEMBER: With the President's announcement of the exploration initiative and your demonstrated success so far in creating a launch vehicle, one could hope that venture capitalists are now flocking to your door offering you additional money or it could be that you -- perhaps, it will require a personal fortune for several more years to make innovative leaps forward. How do you see it playing out? Are standard sources of capital going to become available to the launch field?

MR. MUSK: Well, the financial strategy at SpaceX is that I'm funding the development through first successful launch and post first successful launch we intend to seek probably significant Series B financing. I have absolute confidence in closing that round very quickly with a successful launch. I think it will be more challenging if it's not a successful launch, but I think with one successful launch under our belt and a manifest of customers, which we will have, it will be a very simple matter to raise capital.

I could raise – I mean, right now I could go to Silicon Valley and talk to people I know who have done well in Zip2 and done well in PayPal and have a cumulative compound return of 10,000 percent literally between the two ventures, and say, "Look, don't you want to invest in SpaceX?" If I said it was a cheese factory, it wouldn't matter. There's some value to that, but I think we want to have investors that are really committed to the business model and believe in it and understand exactly the pros and cons of what we're doing. I think we'll have a very compelling case at the end of this year.

AUDIENCE MEMBER: Are you going to do the reusable first stage for the Merlin 5?

MR. MUSK: The Falcon 5?

AUDIENCE MEMBER: I mean, the Falcon 5, I'm sorry.

MR. MUSK: Which has five Merlin engines. Yeah, so you're asking the --

AUDIENCE MEMBER: The cost and how you're going to do the reusable --

MR. MUSK: Sure, the cost of Falcon 5 is actually only $12 million, only 12. There are many more engines. It also costs us less when we make a whole bunch of engines at a time. A lot of the costs stay the same, but all the avionics are identical. There's no change to the cost on that front.

Making an 11-foot diameter structure versus a five and a half foot diameter structure is also not a huge increment in cost. Where we did a ground-up analysis of what it costs us to make a Falcon 5, it actually only ended up being twice as much as a Falcon 1. There are pretty substantial economies of scale there. Falcon 5 actually has six times the payload of Falcon 1 with a kerosene upper stage and actually probably 12 times the payload with a hydrogen upper stage like RL-10. With a standard kerosene upper stage, $12 million, so you're actually talking about altitude – a good-sized altitude for about $12 million bucks plus range fees. Range fees are about three-quarters of a million dollars or somewhere in that region, so around 13ish all in.

Reusability, it will be the same as Falcon 1, would come back via parachute to a water landing, be picked up and taken back for examination and refurbishment. Actually, in that case, I feel a little better about Falcon 5 because of that engine out redundancy. You know, if we miss something on the engine, then Falcon 5 is okay. It can actually complete its mission losing up to three engines depending upon the phase of flight, starting with one and then gradually more and more. The only difference in the recovery system would obviously be a bigger parachute. That's basically it.

The parachute system we use, by the way, is made by Irvin Aerospace which also makes the Shuttle solid rocket booster recovery system and I think the only difference is really -- well, ours is much simpler, and there are probably two digits erased from the price.

AUDIENCE MEMBER: Just a quick question about the recovery operations for that particular vehicle. Have you guys worked on designing the saline issues that you have with an ocean recovery and the impact and all of those other types of things because in Shuttle over the years there have been some issues that we've had to deal with, as well as the tracking and type of recovery that you guys might be looking to do for that one?

MR. MUSK: Sure. Actually, if you – and by the way, for anyone that's interested in learning more than what I've just talked about here today, we have quite a bit of information on the SpaceX website. We publish a monthly update on our progress. So as far as the marine water protection, we've taken a lot of steps to ensure that it's marine water tolerant and that we've minimized galvanic potentials wherever we can. We'll have sacrificial anode or cathode. There's corrosion protection throughout the engine, in some cases multiple layers of corrosion protection.

We actually have an IPA flush of the turbo-pump to clean our propellants on the way down–. The turbo-pump cleans itself out on the way down and then maintains a helium purge which can maintain for up to a few days to insure that it doesn't get any sea water in sensitive parts. It's a lot of small steps. I think it would be very difficult -- if we had not taken this into account in the beginning in designing the engine, I think it would be a very difficult thing to retrofit. I think at this point we feel pretty good about it.

We've done some salinazation tests of engine components. They don't even notice that they're in seawater. One of the advantages of having an ablative nozzle is that that's what hits the water first, so the ablative nozzle actually serves a dual purpose. Its secondary purpose is to serve as an impact attenuator for when the rocket hits the water.

For location, wow, we've got a lot of means. We're going to find the sucker. Let me see if I can remember all the methods of how we're going to find it. We'll have a radar fix, so ballistic prediction plus radar fix. We'll have GPS data in the telemetry sphere. We have a radio locator beacon. We have two sonar locator beacons, one on the forward end and one on the aft end, so we know if the two are not close together there's an issue.

(Laughter)

We're going to get something back. It might just be a couple sonar beacons attached to some scorched aluminum, but we're going to get something back. Then we also have a GPS tracker that communicates by Globalstar, so the vehicle actually calls us and tells us its location. In addition to that we have a spotter plane, so we'll find it.

MR. VINTER: We have time for one more question.

AUDIENCE MEMBER: What do you see as your role in the exploration initiative of Mars and beyond?

MR. MUSK: Let's see, let's see, our role in, let's see, Mars and beyond or -- well, we have a strong interest in long term human transportation and we also have a strong interest in our vehicles supporting some of missions that will go before the manned missions for sample and return potentially. I hope that we have actually a fairly substantial role. I think the timing is really well synchronized with our development. As the needs develop for the President's new Mars initiative, I think we will be well positioned to help NASA meet the President's objectives under schedule and under budget. Thanks.

(Applause.)

MS. McARTHUR: All right, thank you, gentlemen. We appreciate it, thank you, and thank you, John. Okay, we'll recess and we'll begin our next panel in a few minutes.

(A brief recess was taken.)

MS. McARTHUR: Ladies and gentlemen, I'd like to request that when you have questions during the Q and A portion of the presentations, you raise your hand so that they can bring you the microphone because our audio/visual people are not getting your questions on the CD that we're taping of this conference, and we'd like to have your input added to the record of this activity.

Okay, next we have our panel on the Emerging Suborbital Market, and that's going to be moderated by Michelle Murray. Michelle Murray has specialized in reusable launch vehicle issues since joining AST. She is working on all of the teams that work RLV license and applicants, and she is serving as the focal point within AST for the X Prize Program.

Michelle is an active member of the RLV operations and maintenance team and is also a member of the AST Human Flight Safety Team where she has led in the development of the section of the suborbital approved RLV guidelines involving environmental control and life support systems. Before coming to AST, Ms. Murray was the lead thermal and power engineer for the Terra Mission for Lockheed Martin Space Operations at Goddard Space Flight Center. She holds a B.S. in Aerospace Engineering from the University of Maryland. It is my pleasure to introduce the moderator of our panel on Emerging Suborbital Markets, Ms. Michelle Murray.

(Applause)

MS. MURRAY: Thank you, Camilla for the introduction. I'm pleased to be here this morning and to have the opportunity to bring together these very distinguished panel members to discuss an exciting new facet of the commercial space transportation industry, the new emerging suborbital market. A lot has happened over the past year since our last conference. The X Prize deadline now looms less than a year away, and the vehicle developers are working furiously to win.

At AST we've also been working to encourage this new emerging market while maintaining a focus on safety. We've published definitions of suborbital rocket and suborbital trajectory. We've developed draft guidelines for suborbital RLV flight crew, and we've published guidelines on RLV operations and maintenance, which you'll hear about more on the next panel, all in anticipation of this suborbital market. Now here we are just a short year later, and we're in the process of evaluating sufficiently complete RLV license applications.

If all goes well, we'll be here back next year at the conference talking about how 2004 was the year of the commercial suborbital RLV. I know you all are anxious to hear from our panelists, so it's my pleasure to introduce Mr. Troy Thrash. Troy is currently a program manager within Futron Corporation, a technology management consulting firm specializing in the aerospace sector.

He manages several large-scale projects for clients, including the Federal Aviation Administration and the U.S. Strategic Command. His projects focus on various facets of the space industry, focusing primarily on launch industry research, analysis, and forecasting. Prior to joining Futron, Troy served as the Aerospace Project and Program Manager for Engineered Multi-Media, Inc., and a Senior Aerospace Engineer for Analytical Graphics, Inc.

Our second speaker will be Gregg Maryniak, and he is the Executive Director of the X Prize Foundation. He formerly served as Chief Executive Officer of the Space Studies Institute of Princeton and as a Senior Scientist of the Futron Corporation where he consulted to NASA, the Federal Aviation Administration, and the aerospace industry. Maryniak is a member of the International Space University, a member of the faculty. The Aerospace Institute of Aeronautics and Astronautics named him a distinguished lecturer for his presentation, "The Harvest of Space." He was awarded Russia's Tsiolkovsky Medal for his work on the use of resources of free space.

He received the Space Frontier Foundation's "Vision to Reality Award" for his role in creating the Lunar Prospector Mission launched in 1998. An instrument-rated commercial pilot with more than 30 years of flight experience, Maryniak was the Flight Director for Erik Lindbergh's recent New Spirit of St. Louis Flights.

Our third panelist will be Mr. Jeff Greason, who has co-founded XCOR in September of 1999 and serves as President. XCOR has developed several generations of long-life reusable rocket engines, a low cost piston pump for rocket propellants and a manned reusable rocket aircraft, the EZ-Rocket which has flown 15 times without mishap. Mr. Greason has been involved with FAA AST since the Notice of Proposed Rulemaking on RLV Licensing first came out in 1998. He commented extensively on the NPRM prior to it becoming a final rule and has commented on most of AST's rulemaking since that time.

He's been an active participant in COMSTAC's RLV Working Group since October `99. Mr. Greason worked closely with FAA and testified before the Joint House/Senate Subcommittee hearings on commercial human space flight to address how the FAA defines the transition from aircraft regulation to launch vehicle regulation for suborbital vehicles.

More recently Mr. Greason has been supervising an RLV launch license application for XCOR which became the first sufficiently complete application for an RLV. Mr. Greason also supported Mohave Airport on their sufficiently complete application to be the first inland commercial launch site for reusable launch vehicles. Mr. Greason holds 18 U.S. patents and a B.S. degree in Engineering from California Institute of Technology.

Our fourth speaker will be Mr. Ken Wong He's a Senior Aerospace Engineer in the Licensing and Safety Division of the FAA's Office of Commercial Space Transportation. Mr. Wong has been with AST since 1996 and has worked on several unique projects involving the safety evaluation of launch activities associated with expendable launch vehicles and reusable launch vehicles. He's been leading an AST Human Flight Safety Team to address commercial human space flight-related issues.

Prior to his present position at the FAA, he's worked for private industry, supporting NASA as a contractor in the area of safety, reliability, maintainability, and quality assurance for both manned and unmanned spacecraft. Mr. Wong has both a B.S. and an M.S. in mechanical engineering from the University of Maryland. With that, I give you Mr. Troy Thrash.

(Applause)

MR. THRASH: Thank you, Michelle, and thank you and good morning to all of you in the audience today. It's actually quite a privilege to be part of this rather all-encompassing suborbital panel and sitting here with the guy who's been a motivational force behind suborbital space for some time, sitting with another guy who's building a rocket to open up the suborbital frontier and another guy who, regardless of what goes up and what comes down, is going to make sure it's done in the safest way possible. As for me, I'm here to talk about what we're going to do when we get up there.

Before I get out my crystal ball and my tarot cards and start reading Jeff Greason's palm, I'd like to give you a little bit of history about suborbital space, so if you could go to the next slide, please.

The use of suborbital rockets has undergone quite a change in the last 45 years as you can see here. Ironically, if you look at the curve, especially for those of you way in the back, it looks like a suborbital flight profile. Probably more sobering is the fact that what you're looking at is a chart of suborbital launches worldwide by year since the beginning of the space race. Now, one important thing to note is that suborbital flights have been defined as anything from a towering Barry Bonds' home run up to about 62 miles.

What you're looking at here are flights above 50 miles in altitude. Obviously, you can see that the peak activity for suborbital flights occurred around the 1969 to 1970 time frame. Since then, there's been 20 years of gradual decline due primarily to reasons number 2 and 3 that are listed there. In 1991, you see a defined break, which has lasted up until now, which is primarily due to the collapse of the former Soviet Union. Next slide, please.

So where are we today? Well, one can argue that suborbital space is in a way grounded at this point, now that we're doing about 3 percent of the launches that we did back in the suborbital heyday. The U.S. today is primarily responsible for most of those launches even though it's, again, a lot less than we used to do. We do about seven missile flights a year for DOD's missile verification. We do another handful for missile defense tests, and we do a lot of sounding rocket research. By sounding rocket research, I'm talking about high-altitude research, astronomical research, microgravity research, things like combustion science, fluid physics that sort of thing. We also do some component testing. but that's basically it. That is the current suborbital market. As I mentioned previously, we've been in a decline for about three and a half decades, and we're really showing no signs of any potential growth here. So the question is, why the optimism? Why is there so much talk on Capitol Hill about suborbitals? Why are we spending so much time here at conferences and panels like this talking about the future of suborbitals? Well, the answer, I think, is that suborbitals are about to undergo a very drastic change.

As my good friend and colleague Phil Smith pointed out when looking at this chart, if you look around the 2003, we're not actually sitting here in a trough of suborbital activity. We're actually looking at something different and something much bigger. Indeed, I think he's right. I think really what we're looking at is a sort of suborbital renaissance. Now, we're always going to be launching missiles. That's perfectly fine, but the suborbital regime of tomorrow, and I guess I may literally mean tomorrow, we'll see, is going to be something very different. We're going to be having new vehicles with new capabilities, new technologies, new ground infrastructure, new everything. So indeed, what we're soon going to be looking at is not your father's suborbital space, and Jeff, that's for you for your first commercial. Next slide, please.

What I'd like to focus on today is the markets that are going to come on-line with this new suborbital regime. About a year and a half ago, the

Department of Commerce put out a study, called "Suborbital Reusable Launch Vehicles and Applicable Markets." In there, they listed and defined a whole bunch of markets, and I certainly suggest to you, you take a look at that because I'm just going to give sort of a cursory overview today.

Now, the first five markets -- I sort of ordered these in my own special way. The first five markets, I think, are going to come on line in the sort of near- to mid-term when suborbitals do, indeed, come on line. One interesting thing about these is they are going to create their own demand for launches. They probably will also take off and land at the same point, which is very important when discussing near- and far-term markets.

Space tourism, the first one there, is certainly not new. It's been talked about for a very long time and realized in 2001 when Dennis Tito went up to the International Space Station for 2 weeks for a mere $60,000.00 an hour. I just want to make sure you're all paying attention here. A year later, Mark Shuttleworth did the same thing and even today Space Adventures and other companies like that are continuing to sign people up for orbital and suborbital space tourist flights.

Space diving is exactly what you think it is. People going up 62 miles and I don't know, strapping on some sort of heat shield and heavy duty parachute and jumping out of suborbitals. And, you know, there are people out there crazy enough to do it, so, indeed, it does have to be listed here as a market.

Microsatellite insertion is probably an old idea whose time has come with suborbitals. I think there's a latent market here because there are a lot of educational institutions who are building satellites but cannot afford to launch them on today's current expendable launch vehicles. If reusable launch vehicles can bring the cost down a little bit, I certainly think there's a market there for them.

Suborbitals also provide sort of a pop-up environment for commercial remote sensing and military surveillance. For example, the military, when suborbitals come on line, will be able to do on-demand intelligence. They will be doing it with a higher frequency and higher resolution than today's satellites. Also there will be less risk than with today's reconnaissance aircraft. The same thing with commercial remote sensing, when we're dealing with monitoring hazards, such as floods or volcanoes or even terrorism, the same sort of thing applies.

The next two, fast package delivery and high-speed transportation, I think these do the same thing in that they are going to create their own demand for launches. The difference is they're probably not going to be happening for another, say, 30 or 40 years. I think, we just need a lot more ground infrastructure than we have right now. The fast package delivery is basically a FedEx for people for whom "absolutely, positively has to be there overnight" just isn't fast enough. The issue here is, first of all, I think it's going to be very important to get the cost per pound down at least into the same order of magnitude as today's transportation systems in order to make this work. Also, we need to build out our ground infrastructure, mainly spaceports, in order to make this work. If you're sitting in Fargo, North Dakota, and you have a package to send to Hong Kong or something, by the time you either drive it or fly it to a spaceport to make it happen, then probably a lot of the advantages will be minimized.

The same thing for high-speed transportation, where now we're talking about people traveling. If you live near a suborbital hub and are flying to another one, then the advantages are there, but if not, probably not.

Finally, media advertising and sponsorship, I have this listed last, but this is a very big market. It has been and will continue to be. This type of thing has been going on for a very long time in space. Film and television, for example, Tom Hanks' "Apollo 13" movie, many of the scenes from the lunar and command modules were filmed on the *Vomit Comet*. I think there were about 600 or so flights dedicated to that. Product endorsements, since John Glenn used his Minolta camera to get shots of astronauts eating M&M's and beef jerky and drinking Tang, that's been going on, and advertising, branding and sponsorship, the same sort of thing. Pizza Hut put their logo on a PROTON rocket. Radio Shack filmed the first commercial in space, so that continues to go on, and it will. You know, it's going to get bigger and bigger. We're going to get to the point where everywhere you can put a logo on anything it's going to happen.

Think like NASCAR going vertical, with fewer left turns. Finally the et cetera, et cetera, et cetera, I'd just like to sit back and think about some of the markets that nobody has thought about yet. Okay, very good, the reason I bring this up is because for example, the early pioneers of GPS sat around and said, "Boy, this is going to be a really great system." I can pretty much guarantee that they didn't think that a couple of decades later there were going to be GPS systems in cars, so guys like me never had to ask for directions. I'm sure they didn't think that a whole bunch of people out there would be buying these GPS receivers to play a global game of hide and seek. The point here is there's so many markets that we have not thought of yet, and it's just going to be wonderful. Next slide, please.

Now, the current status of space tourism, which is what I really want to focus on for the next few minutes. Space tourism has really focused at this point on orbital launches. Right now there are no suborbital vehicles to take people into space. Again, we're looking for them to come on line very soon. There are issues, certainly. There are technical issues, there are regulatory issues, and there are, of course, investment issues as I'm sure Jeff will attest. One thing that we found at Futron as far as investment issues were that investors were quite unwilling to part with their money for suborbital vehicles because there wasn't any sort of unbiased accurate study quantifying the suborbital space tourism market.

You see reasons here. There were some studies put out, but they were debunked for some of the following reasons. The studies were done by advocates of space tourism, so basically the perception was that the numbers were inflated for a biased agenda, and you know, true or not, the perception stands. The survey pool was inappropriate. The price points were unrealistic, and finally, the description of space experience was not balanced, meaning everybody heard about the good things about going to space, but none of the bad. Next slide, please.

So two years ago we decided to get together with Zogby International to perform what we believe to be the most realistic space tourism survey to date. We surveyed 450 qualified applicants. The surveys took about 30 minutes or so, and this is how we addressed some of the shortcomings of the previous studies. We have no vested interest in space tourism or any other organization. The survey pool was restricted to basically people who could afford to go.

We used a range of realistic price points. For suborbital, we said from $25,000.00 to $250,000.00. The $25,000, I know sounds a little strange because the current going rate is about $100,000, but we figured 20 years from now with a whole bunch of launch vehicles and a lot of people going, prices will, indeed, come down. Finally, the description of space travel was vetted by a former Shuttle commander and current Futron employee, Brian O'Connor. Next slide, please.

This is what we told people was going to happen when you went into space. You'll fly in a safe vehicle, 50 miles high. You'll feel acceleration like you've never felt before, where less than 1,000 people have ever gone. From there, you'll get to see the curvature of the earth. You'll get to float around in a weightless environment, so does that sound good? Do you think you're ready to sign up? Well, there are a few things we forgot to tell you, and here they are.

It actually is a rather risky endeavor, especially for those of you flying early on with some less than proven technology. Also, you'll be investing a week of your life to go on this 15-minute trip. By the way, you won't be able to float around. You'll actually be strapped to your seat the whole time, but you will be in a micro-gravity environment. I suggest you not eat too much before the trip for fear your stomach may not want to talk to you afterwards. Do you still want to go? Next slide, please.

We got the results back, and we pored over them for about 8 months. We came up with a couple of different things: a profile of the most likely customer, and a 20-year revenue and passenger forecast, which I will show you in just a minute. Finally, customer preferences were identified: what people really liked, why people really wanted to go, and what some of the major turnoffs were.

Next slide, please.

This slide shows a couple of examples of the charts that we have in our study. If you'd look on the left-hand side, probably the most important thing is 19 percent of all of the respondents said that they are either definitely likely or very likely to go on a suborbital trip, and that's after telling them everything, the good and the bad. One important thing to note is that we did this -- we asked the same sort of question after only telling them the good things. About 30 percent of people said they are definitely likely or very likely to go, so about a third of those people dropped out once we told them that, "Well, things are not as rosy as you think."

If you look on the right-hand side, you see one thing to point out is that about 30 percent of people are willing at this point to pay the going rate of $100,000.00 for a trip. If you bring that down to $25,000.00 a trip, you see over half of the respondents say they are willing to pay to go. Next slide please.

This is sort of the crown jewel. This is our suborbital travel forecast which goes out into 2021. The purple line there denotes the number of passengers that we expect to be going. Those are measured on the left-hand Y-axis. The light blue is the amount of revenue that will be associated with those flights, and that's measured on the right-hand Y-axis. Now, we have this starting in 2006. Whether you believe it's going to start in 2004 or 2014, that is okay. This growth profile works on a sliding scale, so it's going to look basically the same even if you need to move the tick marks back and forth. The most important thing to notice here is that in the year 2021, we're looking at over 15,000 passengers annually going to sub-orbit to the tune of almost $800 million in revenue.

Now, if we extended this out a couple of years, I would say we're probably looking at a billion dollars in revenue annually, so this is no doubt a very serious business. Now, a lot has to happen between now and then. Certainly, you know, all the vehicle schedules need to remain intact. A lot has to not happen also; for example, a string of major failures, but this can certainly be done. If it does, I think a lot of people are going to be reaping a lot of rewards. Next slide, please.

The last two slides, I just want to show you how the suborbital launches and revenue fit into the grander launch scheme especially from an FAA perspective. What you're looking at here is AST license launches from 1999 through 2008 taken from a data base and a couple of forecasts, one of which I just showed you. The important thing to note here is the orbital launches in red are going to remain flat in the out years, while the suborbital launches are, pardon the pun, about to take off. What this means for Patti and her licensing group is you're going to be very busy, very soon. Next slide, please.

Okay, this is the same sort of chart, but now you're looking at the revenues that are associated with these launches. It's quite a different scene from the last chart. What you're looking at there is in 2006, `07 and `08, though there are a lot more suborbital launches, the revenue continues to be dwarfed by the revenue from orbital launches. Now, if we actually take this chart out to about the year 2016, that is when we expect the suborbital launches revenue to actually overtake those of the orbital and that, of course, assumes that there is no orbital space tourism market here as well.

In closing, I would just like to say that the suborbital space markets are not really stuck in a "Field of Dreams" type paradigm, where if you build it, they will come, or in the case of space divers, if you build it, they will jump. Actually, I think what we're looking at here is “hurry up and build it because we're already here, and we can't wait to go” sort of paradigm. That means the responsibility to ignite these markets and really get things going lies on -- you know, on the shoulders of Jeff and John Carmack and Burt Rutan and anyone else who's currently bending metal into rockets. At this point, I think it's up to you guys. The markets are there, and I suspect that's the way you like it. Thank you very much.

(Applause)

MS. MURRAY: Okay, we're going to hold questions until all the panelists have had a chance to speak. Our next speaker is Gregg Maryniak, the Executive Director of X Prize.

MR. MARYNIAK: Good morning. It occurs to me that probably everybody in this room makes most of their living from being in the space business, so what that really means is I'm surrounded by the most courageous people on the planet or the most gullible. I think, like me, you fell for that commercial that said, "Go into space, you can earn as much as some poets." Well, I agree with Troy, that there is a future in this, and the future is now. We are all aware of the famous Chinese curse, "May you live in interesting times." Have we got some signal, guys? Signal would be good. There we go, thank you.

Well, I think 2004 is going to be a very interesting year. We heard from Elon this morning. It looks like this is his year for getting their new vehicle going. And we firmly believe that this is the year that we're going to have to part with $10 million in the X Prize. A lot of that is due to the courageous help of people in this room. Patti Grace Smith was at the announcement of the X Prize in St. Louis in 1996 when all we had were viewgraphs, and our unofficial motto, which we need to translate into Latin, is "Hardware talks, viewgraphs walk." So with that I'll show you some viewgraphs but maybe some hardware as well.

I think most of you know about the X Prize. It is a $10 million prize to the first private outfit that flies a three-place ship, a three-person ship, twice within 2 weeks to prove its reusability to 100 kilometers altitude, to space altitude. And why? Because we want to foment the creation of the vehicles for space barnstorming, the vehicles that will take folks like you and me into space.

We've lived through a sea change where what everybody knew about an industry changed utterly within a period of just a few years. Everybody knew that a computer was a multi-million dollar artifact that was owned by governments or large businesses. Then what everybody knew changed almost overnight, in about a five-year period, from 19 – roughly `76 or so when the first Apple IIs came out to about 1981 when the IBM PC came out.

The same thing happened in aviation and in an even shorter time frame. The best example is what happened after Charles Lindbergh flew in 1927. Within a year of Lindbergh's flight, the number of pilots in America tripled. The number of airplanes licensed in America quadrupled. If you're statistically naive, you think one-fourth of those were UAVs [uninhabited aerial vehicles]. The most amazing number is -- and this is from Scott Berg's Pulitzer Prize winning biography of Lindbergh -- the number of commercial passengers in America went up by a factor of 30 to 180,000 people by the end of 1928. Why? Because people got it.

Suddenly, people got that they could go, that it would be part of their lives, or at least that it was an okay thing for your brother or sister to do. It was a legitimate activity. I think we'll see an ignition point which will make Troy's prediction of 20, 30 years look too long but I'd like to commend Troy and Joe Fuller on their courage for doing things like using their own money to do this Futron/Zogby study, which is a real service to this industry. We're seeing a lot of juice about the X Prize now.

People are beginning to watch it. I can walk around with my little pen and people say, "Oh, I know what that is," and we're setting up because we think the competition is going to happen this year. We've established our mission control center which we'll use during the flights as our PR outlet. I'll show you what that looks like when it's rocking and rolling, maybe, I hope. We've got sound? Sound guys? That's probably my fault. Go to Plan B.

(Video shown)

I invite you to come to St. Louis where Mission Control is located, and walk down the hall on the way to it, and see an exposition of the 27 teams and the various technical modalities that they're using to try to skin this cat. It makes for a great story for students of how engineering and trade space analysis is done, but the real excitement is that people are bending metal and firing engines.

Here is the test stand of our Canadian Arrow Team in London, Ontario, which has done some interesting industrial archeology and is now firing real honest to God reconstituted V-2 engines. Built from scratch, but it's the real V-2. If we have time, I'll show you a little bonus film of this engine firing which I showed to Conrad Dannenberg, who was one of the lead propulsion guys on V-2, who is in his nineties. He was pretty excited. He said, "Ah, they're running it with too much pressure on the propellants."

One of our British teams, Starchaser Industries, which have been firing the largest rockets launched in Great Britain in the last 20 years, is testing its space capsule and recovery system. Let me show you a bit of that. Let's see if we can get sound. I'm not hearing anything. This was in Kingman, Arizona, this summer. How is that for an E-ticket ride. This is a piloted capsule.

(Video played)

The woman in the back is Steve Bennett's wife, Adrian, and she's kind of happy because Steve's going to be flying it next.

(Video played)

When you think about it, the amazing thing is these are piloted. It totally changes your intention when you have a piloted vehicle. Your procedures are different.

(Video played)

They're very happy because they weren't sure if this was going to come down kind of flat and rip the wheels off, and it obviously did not. There's a lot of enthusiasm. Of course, meanwhile, back in this country, here's Armadillo Aerospace testing their recovery system and their crushable nose cap. They may not use this design now. They've got some changes. It still makes for fun testing, however.

Some of you that know my background know that I started my career as a tort lawyer, but I got better, and I'm looking at those houses and saying, "Oh, gosh." Now this has a sheet metal conical cone which is designed to absorb a lot of the impact, and it does. Murphy's Law comes into play and it lands behind some trees, so you can't immediately see the crushable nose, but the camera on the vehicle itself will capture it.

It worked. This one takes a moment to load. This is the first glide test of SpaceShipOne, Burt Rutan's vehicle in Mohave, and this was this past summer.

(Video played)

The caption of this movie put in the form of a question is, "How do you get a test pilot to take a bath?" Well, what happens after the X Prize is won, hopefully this year? Well, as the -- here's a less scientific survey than the Futron/Zogby study. It pretty much mirrors the results that I've seen in polls for the last 10 years, ranging from very carefully scientifically crafted Japanese survey instruments to joke Internet surveys. Roughly 7 out of 10 people in the developed world say that if they could buy a ticket to take a ride into space, they'd buy one. Everybody has different price points, ranging from Dennis Tito's 20 million down to folks like me who might trade in my hail-damaged Dodge Intrepid to pay for a ride. But in fact, Dennis Tito has joined the board of X Prize and he said, "Do you know what, I always dreamed of flying in space. I was up there for 8 days, and it was really glorious, but it didn't take me 8 days to figure out that I made it." He said, "I looked out the window. It took about 8 seconds. I looked out the window, Earth is there, I'm here, wow."

He said, "When people can fly into space for the price of a car, it will mean millions will go, and it will change the economics of space flight forever." Exactly right. Our mission in life has been to provide a context, an exciting milieu that can allow the modern day Orvilles and Wilburs -- and keep in mind the bicycle mechanics from Dayton beat the government-funded guy, Sam Langley, 100 years ago. We're trying to keep these guys in bread and butter, and that means sponsorship. It means making an exciting race where they can go out and get people to invest money.

Our next step, which you've probably read about, is something called the X Prize Cup and Public Space Flight Exhibition. We've put out an RFP last summer, and we've narrowed down that respondents to two finalists, New Mexico, -- and in fact, Lou Gomez from New Mexico is here with us today, -- and Florida. We'll make a selection this year on the site for an annual activity which will be sort of a cross between the old national air races – you saw the movie "The Rocketeer"? They talked about "going to the Nationals". Well, those were huge. Eight hundred thousand people would show up in places like Cleveland or Miami. The people who won those contests were nationally famous, people like Roscoe Turner, flying with his lion cub Gilmore, you know, amazing stories. Well, we're going to make those amazing stories again, so that the modern day heroes can bring their vehicles to one place, and people can see them.

People are coming around to understand the absolutely pivotal requirement for regulation. This isn't just another silly poll on our website. You have to be leery of surveys. I saw one survey yesterday that said, "Nine out of 10 doctors believe that 1 out of 10 doctors is an idiot."

(Laughter)

But this survey says that about 60 percent of the population, including the space-aware population, believes that there's an important role for the government, so watch for some excitement, I see that I have a minute and 52 seconds, so let me give you a little encore, maybe two.

(Video shown)

This is London Ontario, roughly 2 days before Thanksgiving.

Of course, those gaps in there were caused by my computer and not by combustion instability. This is a little bit of a press release. Paul Allen has now been officially outed as the secret commercial backer of Burt Rutan's enterprise, and this is the first privately developed aircraft to go supersonic. It went supersonic on the hundredth anniversary of Orville and Wilbur's flight. Pilot Brian Binnie launched from about 48,000 feet and flew to almost 70,000 feet, hitting Mach 1.2 with a vehicle powered by rubber tires and laughing gas, so stand by for adventure. Thanks a lot.

(Applause)

MR. GREASON: I thought about bringing a bunch of video and decided not to because I figured by this point most of you have seen it. The EZ-Rocket has been flying for a year and a half or 2 years and that's -- I'm embarrassed to show stuff that old. But then I realized I'm going to a town that's full of people who work on programs that take 15 years from concept to flight. I should show at least a little bit of video, so we've got kind of our XCOR in 30 seconds thing here. Then I'll move onto the rest of the presentation. Yeah, I hope we get sound.

(Video played)

Go ahead and turn that off. I was preparing the conventional aerospace PowerPoint presentation about the middle of last week, and I was putting myself to sleep doing it, so I thought I would spare you that experience and speak without notes. All of the people at this table, most of the people in this audience have an important role to play in the process of trying to make some dramatic change in the way we make space happen. My role, unfortunately, is very similar to that of one of the two lawyers in the adversarial process of a jury trial.

It's my job to come to Washington and be unhappy. You know, it's my job to come to Washington to complain about what we're not doing fast enough, complain about what we're not doing good enough, complain about what we can do faster, complain about the changes that we want to make. That's my job. That doesn't mean that that's the only thing I like doing or the only thing I'm happy doing. It's my role in the process, and if I wasn't doing it, somebody else would have to.

In addition to being the twentieth year of commercial space transportation, this is a much less significant anniversary. This is the tenth year of my decision to leave a perfectly good job, drink the Kool-Aid -- as one of my marketing guy says, get into the space business, take vows of poverty and chastity, and move out into the middle of the desert -- all those things. So I thought it was at least okay this once maybe briefly for me to look back over the last 10 years and see just how far we have all come together because it's really an incredibly long way.

I remember 10 years ago very vividly that there was a conference in Phoenix, Arizona, that led to my getting into this business. And you know, a bunch of no-name guys who were there, like Gary Hudson and Mitch Clapp and Mike Kelly and Walt Kistler and a bunch of people who all went on and had space companies in the next 3 years. And it was all NASA at the time. At this meeting of entrepreneurs, the radical fringe of space access, the headliner in every program was NASA. The second headliner in every program was somebody from Lockheed, Martin Marietta, Northrop, Grumman, General Dynamics, or all those companies that are mostly gone now.

And quietly, at the end of every session, some really radical nut would get up and say, "You know, that's all great, and that's where the future is going to be, but you know, it's possible, maybe in the future some day there might be private space activity. Of course, that will always only be a sideline." The Shuttle-Mir Program was the big news in 1994. You know, we were going to have these routine flights of an American space transportation system to a Russian space station in preparation for the grand and glorious endeavor of the International Space Station. DC-X had just flown, which was definitely a seminal event that led to a lot of us getting into this business and was the acknowledgment that it could be done. There were a lot of well-intentioned idiots like myself that were out lobbying for the effort that would eventually become X-33.

And there really wasn't -- you know, late at night over a beer some people would occasionally talk about the notion that maybe some day tourists might fly. Things have moved so far now. I realized very sharply recently when Time magazine ran their analysis article of the Bush Administration's plan to return to the Moon, and they called us up for our comments because they were running the facing page piece, a half-page bit on what's happening in commercial space. I said, "Why are you doing that? " and they said, "Well, you can't run an article about going back to the Moon without a counterpoint piece on what's happening in the private sector." Think about that one for a second. The national media can't talk about what's going on in national space policy without talking about what's happening in the private sector. That's how far things have come. Space tourists have flown to orbit to the space station – from Russia, because they couldn't find a way to do it in the United States – that's how far things have come.

We're debating in Congress now, and legislation just moved out of the House committee, to put in place the regulatory and legal structure to allow for paying passengers to fly on American space vehicles at their own risk because that's what it's going to take to get the market started. That's how far things have come. Things have come so far that had you told us 10 years ago that it would have gone that far, we would never have believed it. So as we go back to the ordinary mode and I go back to performing my function of pointing out those things and the mountains that still lie ahead and that road that we still have to go and the distance we still have to cover, please bear in mind, that does not mean I or anybody else is ignorant of how far we've already come and how far we've moved together and how far the conversation has changed.

One other thing to note is in the last 2 years three private companies have now flown 24 test flights by my count of manned rocket vehicles. That's not counting un-powered flights, and that includes, of course, the very significant milestone of Scaled's rocket-powered supersonic flight on December 17th of last year. None of those have yet been licensed as a space launch vehicle, but that is very, very close. Those are all sub-scale demonstrators or earlier test flights of one kind or another.

Again, I think 2 years ago if you had said that that was going to be the case, even that would have seemed a bit incredible. As was said earlier, this is all happening because of excitement about suborbital markets. All these vehicles that have achieved those milestones in the last few years, including our own, are all targeted for the suborbital markets. Another thing interesting thing is 10 years ago there was one guy, and it wasn't me, talking about suborbital markets. I thought he was crazy because the revenue per flight on a suborbital vehicle is so low. How could you ever make money?

I have now come to see that that is not a bug, that is a feature. The fact that the revenue is so low is what forces us, the entrepreneurs, to think that the only way we can make enough revenue to be meaningful is we have to fly a lot. The only way you're going to be able to fly a lot and make money on a per flight basis is your cost per flight has to be even lower than the already low number of revenue per flight. So the only possible way we can make money in the suborbital business is – if you're talking about vehicles with tens or hundreds of flights per year, you're talking about vehicles with a marginal cost per flight that's thousands or tens of thousands of dollars at most.

If we can do that, we will make a reasonable amount of money. You know, as the Futron guys have correctly said, maybe hundreds of million dollars per year as an industry, and that's not peanuts. If we can do that, we are going to know how to build bigger and more capable vehicles in the future. Those bigger and more capable vehicles are going to cost 10 times more per flight than orbital vehicles, and now you're talking -- than suborbital vehicles, excuse me. Then, you're still talking about routine orbital flights with tens or hundreds of flights per year and per flight cost in the hundreds of thousands of dollars, or let's be extravagant, millions of dollars. That is beyond our wildest expectations for what we can do in orbital flight right now.

The only way we're going to learn how to do that is to do it on a smaller scale earlier and show we can make money doing it. That's why suborbital is a big deal. That's why it has big implications that stretch far beyond the important and significant but still relatively narrow niches of suborbital tourism or microgravity or microsatellite launch. One of those big implications is for our friends in the FAA. When orbital – when reusable launch vehicle regulation was developed, I remember the NPRM and the cost analysis that showed that the regulatory burden was not significant. That was based on the explicit assumption that a typical reusable launch vehicle flight would have $50 million of revenue.

I think that's much more likely to be closer to $50,000.00 of revenue and hundreds of flights per year. When you're talking about that kind of market, the amount of regulatory burden that constitutes a negligible cost is maybe a few thousand dollars per flight of regulatory compliance cost. We have a long way to go yet before we can get to that point. I know that you know that and you know that I know that, and we all know it's going to take a lot of work and a lot of time, and that's the job that lies ahead of us.

Suborbital is also going to be where we develop the regulatory framework for commercial human space flight, and that's good. It's a baby step. There's a lot of medical uncertainties. There's a lot of life support uncertainties about just how we're going to handle supporting the general public in long-duration orbital flight. We don't have to deal with all those questions at the first step of going suborbital, but there are still a lot of issues for us to deal with.

I will not dwell on the size of the market. The Futron people have already done that better than I could. I'll only say one thing. There's a sanity check though, too, that you can do to say are these numbers realistic? You can look at things like the warbird flight market which has on the order of 100 people a year flying right now at $10,000.00 per flight. Plus they have to go to Russia because they can't figure out a way to do it here.

This year there will be over 500 participants trying to climb

Everest at over $50,000.00 a head. Thirty percent of them will actually reach the top of the mountain. Three percent of them will die. A hundred percent of them will be miserable. So that, you know, it is not wildly insane, even without detailed market analysis, to look at this market and say if you're talking about $50 or $100,000 per flight, yeah, you're going to find hundreds of people that are going to want to take that trip. As the market matures and the price comes down, the public gets more comfortable. You would expect that market to grow. so just basic sanity check, the Zogby numbers look vaguely credible.

As was correctly said, that's going to produce a market in which you won't even be able to see the number of orbital launches when you look at the overall number of launches. You won't even be able to see the suborbital revenue when you look at the overall revenue picture. That's going to be a big challenge, a big challenge in changing the way we think about it, a big challenge in the way we regulate it.

One or two other markets I want to mention that my predecessors did not dwell on is reconnaissance. That has military terms, and it's a military market of significance, but it's also a civilian market. The total aerial photomapping market is not small. The total satellite data market is not small. Having the ability for that kind of dollars to get on demand imagery at the time and place of your choosing is not insignificant.

Microgravity research has a pretty bad name because so little has been produced by it, but I point out to you that the available tools, the sounding rocket missions out there, have a time that it takes to cycle through the experiment that is so long that it is totally outside the bounds of industrial research, and industrial research is where the money is at in this country.

If you want to be able to do industrial research, you have to be able to do enough experiments in 6 months or 1 year that you have a chance at developing your product or process. You can't possibly do that on an existing sounding rocket, but you probably can do it with a reusable. Hardware tests and qualification, both for private and government customers, is a market I think that shows a lot of promise.

In closing, we've gotten the EZ Rocket cost per flight down to $900.00. Our revenue-generating vehicle, we're still putting the money together on it, so I can't put a schedule on it. It's going to cost more than that but not 10 times more. SpaceShipOne is showing that the private companies can take their performance to the levels that we need to. We've shown that we can get the flight rates and the hours for flight that we need to. The regulations from our friends in the FAA are getting where they need to. Congress is taking the steps that it needs to in order to give us the legal framework to make a business. We're not there yet, but we're getting awfully close. That's it.

(Applause)

MS. MURRAY: Our next speaker is Ken Wong from AST.

MR. WONG: Good morning. As our distinguished panel members mentioned this morning, this suborbital market looks very promising. Now I'm going to address how the FAA, AST in particular, is addressing the suborbital market so as to enable it to occur, but at the same time, to insure that AST performs its primary function. One of the things that AST has done to position ourselves to be able to address the suborbital market and to address issues related to commercial human space flight is that we've established an internal human space flight team, and this team is very diverse.

The makeup of this team has been helped by the increase in staff. Within a couple of years, as you know, AST has increased its staff. This increase in staff has complemented the staff that existed before. The additional staff has come from industry and government, and it's provided significant expertise in areas, such as propulsion, avionics, and flight safety analysis. We also had a member on the team who supported the *Columbia* accident investigation team. His expertise was debris analysis.

Having this additional staff has really helped AST to be able to meet these new challenges and evaluate these new proposed RLV missions which I will talk about later. Okay, one of the major items that the AST human space flight team did was prepare an internal White Paper. This internal White Paper was to identify and evaluate a lot of these policy-related issues. As most of you know, recent legislation from the House Science Committee passed the HR 3752 Bill which tried to clarify the government's role in regulating the commercial human space flight. What we did was – with this internal AST team prior to the Bill coming out, we were already trying to evaluate, identify policy-related issues such that if the market did take off, AST would be in position to either prepare guidelines or prepare regulations if necessary. Next chart.

These are some of the safety flight issues that the AST Human Space Flight Team addressed. The first one is, now that you have humans on board, how does that change the regulatory approach? To date, AST has licensed unmanned launches. Our primary responsibility currently is to insure public safety. When I mean public safety, I mean, the uninvolved public.

Another issue that the team discussed was, should there be risk criteria or limits for those humans on board because our current regulations have risk criteria associated with protecting the uninvolved public, but the question is, how about the crew and the passengers on board? Should there be a risk level, and if there is a risk level, should it be different for crew versus passengers?

The third issue that the team investigated was, let's assume that AST does have the authority to regulate passengers on board RLVs. The question the team looked at is what type of regulations or standards should be in place? When I talk about regulations or standards, I'm talking about from the vehicle standpoint and also from the human standpoint.

The fourth issue deals with liability and liability risk sharing. In the event that let's say you have an RLV, and you have people on board. If a mishap were to happen and you had third party people, the uninvolved public, maybe hurt or the people on board maybe hurt, what should be the liability, and what should be the insurance requirements? Okay, next chart, please.

One of the things that AST was involved with was developing vehicle guidelines associated with humans on board, and the Aerospace Corporation, which is a non-profit organization, provided support to AST in this area. The primary task dealt with developing guidelines for safety-critical systems on board these RLVs. This task involved trying to review lessons learned from – you know, from the military, from the aviation side, from NASA. The ultimate product was a report with a set of guidelines. Next chart, please.

Okay, another thing that the team was involved with was the development of draft crew guidelines. What we're trying to do within AST is to take a proactive approach, so we decided that in the near future -- we saw that suborbital missions are the near-term activity in terms of humans on board; you know, orbital missions we could see downstream. Therefore, the team focused on developing draft crew guidelines for these suborbital missions. These guidelines were briefed at the COMSTAC, which is the Commercial Space Transportation Advisory Committee. It was briefed to the RLV Working Group and to industry last October, and they are available on our AST website. Next chart, please.

In terms of what these draft crew guidelines address, they address crew qualification and training. They also deal with the medical aspects of the crew. They deal with the environmental control and life support systems in terms of, you know, the atmosphere conditions to insure that the crew or passengers on board are kept alive. One thing I will note about the ECLSS system there is that CAMI, which is the medical research wing of the FAA's Office of Aerospace Medicine, has been involved from that standpoint. They have an R&D project under AST to help us develop the ECLSS requirements. If everything goes as planned, we'll probably have a briefing at the next COMSTAC meeting on this R&D project..

The last thing about the draft guidelines deals with human factors. When we talk about human factors, that's to insure that the crew on board is not overworked, that the crew is able to see the displays or reach the displays under the launch environment, like under the accelerations and vibration and the noise. Okay, next chart, please.

Last year there was a lot of uncertainty from industry in terms of: We have this suborbital vehicle. It has wings and it has a person on board. A lot of the uncertainty was, is that an airplane that requires certification under FAA's AVR line of business, or is it a suborbital rocket on a suborbital trajectory that requires a license from AST? I think that Jeff alluded to that uncertainty. It wasn't an easy answer because these are hybrid vehicles. As I mentioned, they looked like airplanes, but at the time, used rocket propulsion, so there was a lot of uncertainty with regards to that. One thing that helped to clarify this was last October AST published in the Federal Register a definition of what a suborbital rocket is and what a suborbital trajectory is, and that helped to clarify it. These definitions are also available on AST's website. Next chart, please.

In July 2003, there was a joint Congressional hearing discussing this uncertainty of whether or not these vehicles would fall under FAA's AVR aircraft certification or AST. I believe Jeff was one of the witnesses. One thing I want to make clear is that today AST does have a regulatory regime in place to address humans on board RLVs, in particular a crew. It's very important to note that, because currently AST is evaluating three license applications, so I just want to make it clear that AST does have a regulatory regime to evaluate these proposed X Prize type missions. What I did was list out two of the major regulations that we are using. One was in September 2000, the final rule for RLV and re-entry licensing regulations, and this, Part 440, is for the financial responsibility. Next chart, please.

Given that we have this regulatory regime that I discussed, there's always room for development of additional regulations. However, these developments of additional regulations, are contingent upon clarification of the government's role in regulating the commercial human space flight. In particular, it's in the area of passengers, especially paying passengers. For the vehicles that propose only to have a pilot or a crew on board, AST feels that it does have the authority to regulate the crew or pilot from the standpoint that the pilot or crew is part of the flight safety system. What I mean by that is, when they're part of the flight safety system, the crew or the pilot can impact where the vehicle is flying.

You don't want the pilot flying the vehicle into a populated area. Therefore, today AST feels that it does have the authority to regulate the safety of the crew from the standpoint of the crew being the flight safety system. However, the passenger part is unclear. This recent legislation, this HR Bill 3752, hopefully, will provide some clarification. It talks about informed passenger consent. In other words, it says that the launch company would have to inform the potential passenger, "This is the safety record or potential risk," but there are still a lot of details that need to be worked out from that standpoint. Depending if this legislation – if it eventually passes, hopefully, it will give clarification in terms of the direction that AST will proceed in terms of establishing additional regulations.

The bottom line is, we feel within AST that with our staff, we're able to meet the challenges, and we're trying to take a proactive approach.

(Applause)

MS. MURRAY: Okay, I'd like remind everyone, if you have questions, please raise your hand. Someone with a microphone will come to you, so that we can capture your question for the proceedings. At this time, we'll take your questions.

AUDIENCE MEMBER: Mr. Thrash, I think your orbital passenger forecast is based upon the Soyuz price of $20 million continuing indefinitely into the future. If that's correct, have you thought about re-running those projections now that Elon Musk has said he intends to carry passengers, and he intends to have a Falcon 5 with a launch cost of only $12 million, which might carry four or five people in each flight, which results in a ticket price of four or five million, which to my mind, is substantially different from $20 million?

MR. THRASH: Yes. Are we on? Okay. Yeah, you're absolutely right. That would definitely change the forecast. Have we thought about doing that? No, not at this point because what we would essentially need to do is change the sort of upper and lower price points where he's talking about $12 million there, and that's just in the beginning. If he happens to win his dinner at his restaurant, that means it's going to be going down from $12 million, so if that's the case, we're going to have to bring it down even more. That's certainly an option, certainly something we can think about looking into in the future, sure.

AUDIENCE MEMBER: A suggestion for Gregg on when you're talking about rocket-powered FedEx. The way the time zones work out, a package that leaves Japan by 9:00 o'clock Tuesday morning will reach the West Coast of the United States by 5:00 o'clock the previous day for those times when it really does have to be there yesterday.

(Laughter)

MR. MARYNIAK: Thank you very much. I'll be sure to use that one. It can be done.

(Laughter)

MS. MURRAY: We have a question up front.

MS. BRECHER: I have two questions. One is to Gregg specifically and one is general. The specific one is you mentioned Steve Jobs and the Apple computer for personal computing, and you mentioned Lindbergh's flight across the ocean as breaking the barrier for exponential growth of the product, but what is the utility that you see for suborbital flights, What do you see as the cascading benefits to humankind from breaking the sound barrier? I mean, you're going to have a lot of unpleasant effects like sonic boom, space sickness. I'm not sure how the risk is transferred. And here is my general question to all of you. Are you making the passenger sign a waiver like a patient going in for an operation that they understand the downside and the risk; therefore, you will not be liable, or just what is the truth in advertising?

MR. MARYNIAK: Good questions, thank you. Let me try the general one first, for a minute. I expect that the document that a passenger should look at and sign will say, "You will probably die on this flight. You must make out your will before you do this flight. Space flight is an intrinsically ultra-hazardous activity which historically has killed 4 percent of the people that have engaged in it in the 433 cases of individual unique humans who have flown in the history of time." It will look very much like the scary language that you see in financial prospectuses which say, "You're a fool to invest in this thing. You will lose your money."

It should say that because we have to have a regime whereby people can take responsibility for their personal risk if this kind of space flight is to have a chance to grow. We're not in the era -- and this is an area where thanks to AST we dodged the bullet, I understand. I've seen some of the discussion of potential Congressional -- potential legislative language that was seeking to provide the same kind of protection for passengers as the FAA provides to the flying public for Part 121 operations, for airline type operations, and we're not there yet. And we will not get there [for a while] – safety is a learning curve effect.

We are in the 1909, 1910 era. I mean, compared to aviation, we're at about 1909, 1910, and amazingly, post-*Columbia*, the fatality rate is statistically identical. It's 3 to 4 percent, so, you know, we have to understand that and know that people will die. I think that's the direction we're going regarding your more general question, and I'll let my colleagues talk about that in a second.

What's the utility of this? The utility is at first the very same utility that existed in the barnstorming era of aviation. You get to see the planet you live on from a totally new perspective. Every woman and man that's flown in space so far has said that it's a life-altering experience. Sociologists have coined the term, "the overview effect," for what pilots who fly for many years achieve in their relationship with the world. Astronauts get it the first time they go up.

Studies that Futron and others have done show that people are very interested in paying lots of money to achieve this thing. Obviously for the first few passengers, there's some snob appeal to being first, "Oh, I got to go before almost anybody else went." That will be a big factor as well, but that's not a small utility, the utility of having this perspective. The fact that 40-some years after the first Everest climb that people still do that just for their own internal benefit is significant.

Now we believe – I think every person on this panel believes – that what we're doing, and Jeff said it extremely well, is that we're trying to take a baby step that's commercially feasible, that paves the way for driving the cost of space down. I still expect to see solar power satellites and solving some of the Earth's major problems happening because of expanding the solution set beyond the biosphere of the planet. It doesn't happen at $10,000.00 a pound to put our tools in orbit. The only way to get that cost down is by doing more of it, so this is the how do you do more of it and get people to pay for you're doing more of it in the early stages?

MR. GREASON: Two quick things on that, on both of those points. I agree with everything Gregg said unreservedly. I'll add only that, yes, there will be 30 pages of fine print, but I don't regard that as an adequate method of disclosure. It will be a necessary method of disclosure, the lawyers will insist on it, but it will not be a sufficient method of disclosure. I think in order for you to be able to defensively argue that you've adequately disclosed the risk to somebody who wants to take that risk, you have to put this in very plain language terms, "You have a 1 in 14 chance of dying on this flight," or something like that. We're also collecting a private little collection of big catastrophic rocket accidents to show them as a video, so they have some idea of what we're talking about by “bad”.

It's worth pointing out, though, that on the one hand we have to be very up front about what the risk is they're taking. It would be ethically incorrect to do anything less. I'm sure that there will be legal and insurance requirements that force us to do it if we had no conscience, but these are reusable vehicles. If there were no regulators, if there were no insurers, if there were no constraints whatsoever other than, you know, sheer greed, if we crash these things more often than about once per thousand flights, we will lose money and the activity will cease, so we have every possible motivation, you know.

The regulations, our ethics, and our greed all point in the same direction. We have to make this endeavor more safe and more reliable than space flight has historically been, or we will not be in business.

On the more general question or the question about what good is it, I resist the suggestion that everything has to be a public good. I do not understand why it's not okay for people to spend money on something that they think is good for them. I don't understand the sense that is very common in the space community. I'm not sure that's what you were saying, but I'm using it as an excuse to address a point that other people have often made. Why should people be able to do whatever they want in space? You know, space should only be for science, or space should only be for international projects, or space should only be for great, grand public goods.

Well, that's what we call freedom. It's okay for people to spend their own money and take their own risk for something that they think is important. It's not up to us to decide whether what Joe wants to do is good for us. It's up to Joe to decide whether what Joe wants to do is good for him, as long as what he's doing doesn't hurt us. There's already more than adequate regulatory framework in place to insure that the uninvolved third parties are kept safe, that the environmental impacts are studied and assessed. Everybody else has already been taken care of.

MR. THRASH: Can I just chime in on that? It's interesting in that people do believe exactly what Jeff said, that space is for the people who go up there and do what they do and come back down. It's for the highly trained. It's for the rich people. I think what we fail to focus on, and this is what I would say, is the sort of very grand utility that I think should also be stressed when talking about orbital missions and even, you know, missions to moon and to Mars, is that there really is a lot of benefit that comes back down here and stays down here.

For example, jobs. We're going to be creating jobs by doing this. We're going to be stimulating the economy. We're going to be stimulating education. We're going to be training people. We're going to be getting people excited about space. Suborbital as a sort of step, we're going to be making people realize that space is about other people. Other people can participate. Other people can benefit from it, so what I think we're really doing here is we're showing people that space is about them. Space is for them, so there is a sort of overall grand utility.

MS. MURRAY: Troy, I have a question for you. You had mentioned in your presentation that there is a profile, the typical person who is willing to pay for suborbital flights. I was wondering if you could tell us what type of people are these?

MR. THRASH: I'm looking for one right now. Not to sort of give away the farm here, but I – what we found out was the typical person who is interested and willing to go on a suborbital flight is about 55 years old. I believe about three-quarters of them were male, and about half of them said they were either in good shape or better to do this. About half of them also said that they spend at least a month out of the year going on vacations and buying cars and things like that. They do a lot of that sort of stuff with their discretionary income. That's the sort of typical person who said they would go.

MS. MURRAY: Okay, I think we have time for one last question, and then we have to go to break.

MR. HAUCK: Rick Hauck, AXA Space. I know that Futron did a fine job of eliminating most of the variables in their study, but I wonder if they missed one of the biggest independent variables in a social interaction, and that is the consent of the spouse. I mean that very seriously. When one puts one's life at risk, you can do that very selfishly, if you're only considering yourself, and that's an appropriate thing to do, but there are certainly family issues that are involved. If that was not addressed in your study, I think that there might be a scaling factor that could be applied to the results.

MR. THRASH: Well, I will just make this comment. It wasn't necessarily openly addressed, but I would hope for the sake of the surveyee that that was in his or her mind when making these decisions, making these choices. Certainly, I for one would do the same thing and be hearing my wife's voice right behind me as I'm answering these questions. No it was not explicitly said, but I certainly hope that was taken into account.

MS. MURRAY: Okay, I'd like to thank my panelists for being part of AST's annual conference this year and part of the panel.

MR. WONG: One last thing, I just want to introduce Dr. Angelo Luisi. He's here from Oklahoma from CAMI.

(Applause)

MS. MURRAY: Okay, I think you all have given us an invaluable insight and perspective around this new emerging market, and I thank you for taking the time to be here today. Thank you.

(Applause)

(A brief recess was taken.)

MS. McARTHUR: Okay, welcome back from your break. I need to give you a little bit of housekeeping information. We're running a little bit behind schedule, so this panel – your agenda, if you could take a look at it, it was slated to start at 10:30 and it's 11:00 o'clock now. So we're going to go ahead and run this panel until noon, and we're going to shorten lunch and schedule it from noon until 1:00 o'clock because we have the tour. If you've ever dealt with DC traffic, you have respect for that highway and the amount of time things take.

We do apologize in advance for the decrease in the amount of time that we're going to have for lunch, but we looked at the schedule and thought that that was the best place to make the adjustment.

Now let me begin. Okay, now we're going to begin the RLV Operations and Maintenance Issues Panel with Chuck Larsen as our moderator. Chuck has over 30 years of experience as an aerospace engineer and manager in the aerospace industry. The first 27 of those years, he was working in private industry for five different companies. He has worked on the Defense Support Program followed by the manned space program at NASA JSC as a ground flight controller in the Mission Control Center on the Apollo, Skylab and Space Shuttle missions. He joined the FAA in the mid-'90's and works on the commercial space transportation R&D effort and is the major interface for the FAA with NASA on their space research and development efforts.

Chuck holds a BSME from UC Berkeley, serves on the Embry Riddle Aeronautical University's Aerospace Engineering Advisory Board, and is an Associate Fellow of the AIAA. He heads the FAA team on Reusable Launch Vehicle Operations and Maintenance Guidelines and Regulations Development for commercial activities which makes him the perfect choice as the moderator for our next panel.

Ladies and gentlemen, I'd like to introduce my colleague and our moderator, Chuck Larsen.

(Applause)

MR. LARSEN: Thank you very much, Camilla and we are the RLV Operations and Maintenance Panel. Our time line is a little short but one of the things we're trying to do is get more efficient in operations so that it will cut down on cost. We're going to have like 15 minutes for each of the presenters.

Then we'll have about a 15-minute question and answer period. We'll try and get out of here crisply at noon, so you all can get to lunch.

Good morning, ladies and gentlemen. I would like to point out, we originally had four panelists but late last week, Mr. Mike Kelly notified me that due to medical reasons, he would not be able to participate. He is also Chair of our COMSTAC RLV Working Group. We'll miss Mike's insightful and always provocative presentations, but we've got some very outstanding panelists here. We all do wish Mike a speedy return to health, and we'll see him, I'm sure, at the COMSTAC RLV Working Group in May. The 19th, I think, is the COMSTAC meeting. The working group meetings are the day before, so that should be May the 18th by my calculations.

We have assembled here a very diverse and knowledgeable panel to enlighten us on the significant issues facing the commercial space transportation industry in the area of RLV, operations and maintenance. The significant issues range from aerospace maintenance technician workforce training, qualifications, and proficiency requirements to lessons learned from decades of operating the only reusable launch vehicle in the world, the Space Shuttle.

They will look into the future, and they'll depict planning that must go into the commercial RLVs of the coming years, some of which are already off the engineering drawing boards and into engineering development and test. They're being tested to show that they can conduct their activities safely and efficiently, especially in the RLV operations and maintenance area. This office has developed draft guidelines for RLV operations and maintenance and has presented them to the COMSTAC RLV Working Group. They've also been presented in a paper delivered at the AIAA Space Programs Conference in Long

Beach last September.

Indeed, this office is in the process of reviewing RLV license applications as the last panelist, Ken Wong, has told you. A key area that is being evaluated as they are looking at these applications is RLV operations and maintenance. We look forward to this panel and what it will bring out in terms of the significant issues affecting this important area of RLV operations and maintenance and how it may help the office in evaluation of the commercial RLV industry to conduct safe, efficient, and economical RLV operations and maintenance activities. So without further ado, let me introduce our panelists.

Dr. Al Koller, who will speak first, is the Executive Director of Aerospace Programs for Brevard Community College and principal investigator for SpaceTEC, the National Science Foundation's National Center of Excellence for Aerospace Technical Education. In these capacities, he provides leadership and program administration for the college's aerospace operations at Kennedy Space Center and Cape Canaveral Air Force Station, and he heads a national consortium of community colleges working in innovative technology transfer.

He holds degrees in math and physics, systems management, and business administration with specializations in management and quantitative methods. In addition to his 12 years of higher education experience at Brevard Community College, Dr. Koller was a NASA engineer and program manager at the Kennedy Space Center for more than 30 years and is President of E3 Company, a private consulting firm. He has taught at several universities, consults for private and public organizations and is nationally published with over 70 papers and presentations in the technical and management fields as well as international education. He serves on the board of the National Space Club Florida Committee and is certified though James Madison University's Institute of Certified Professional Managers. In April 2001, he was named to receive the Florida Space Business Round table's Explorer Award recognizing excellence in space education and research programs.

Our second speaker is Mr. Jeff Spaulding. Jeff is a Shuttle Test Director at NASA's John F. Kennedy Space Center. He is one of two certified test directors responsible for leading the Shuttle launch team during the planning, scheduling, and execution of the Shuttle launch countdown. Mr. Spaulding began his career at NASA in 1987 as a NASA operations engineer overseeing Orbiter floor processing activities and has served as a NASA Test Director and Launch Recovery Director, managing control room operations for both Shuttle processing and landing activities. He was selected to his current position of Shuttle Test Director in the year 2000 and has directed eight launch countdowns from that post.

Born in Rockford, Illinois, Mr. Spaulding received a Bachelor of Science Degree in Mechanical Engineering in 1987 from Southern Illinois University at Carbondale. He continued in his studies while working for NASA and received a Master of Science Degree in Space Systems from Florida Institute of Technology in 1993 and a Master of Science Degree in Engineering Management in 1996 from the University of Central Florida. He now resides on Merritt Island, Florida, with his wife, Carolynne and their three children where they enjoy outdoor activities, swimming, and tennis.

Our third speaker and our clean-up hitter is Les Kovacs. Les is the Operations Manager for Orbital Sciences Advance Programs Group. He has 19 years combined experience in military and commercial space operations. His recent experience includes leading ground and flight operations architecture efforts for the combined Orbital and Northrop Grumman team's second generation RLV, crew taxi vehicle and orbital space plane studies and is Operations Manager for the X-34 Advanced Technology Demonstrator Rocket Plane.

His previous experience includes posts as Government Launch Controller, Accident Review Board Chairman, and Chief, Standardization and Evaluation for Atlas IIAS launch operations at Complex 36, Cape Canaveral Air Station and as Chief of Operations Training for Cape Canaveral's Range Mission Flight Control and Range Weather Operations.

I'd like to ask Dr. Al Koller, our first speaker to come to the podium.

DR. KOLLER: Good morning, ladies and gentlemen. Thank you, Chuck and thanks to Dr. Nield and to Patti Grace Smith for the invitation to come and speak to this very important session, very positive, especially compared to last year, if you were here. I'm just delighted to see the rollout of many, many new initiatives that I think are essential to our future.

I'm going to show some charts here in just a few minutes. They're not in your handout because when I made those charts it was a week ago and the deadline was like the 15th. In your packet, however, is a paper, I think it may be the only paper in that packet, that outlines in some detail the philosophy and background, the operation and the results of SpaceTEC over the last year. I would commend that to your reading. I'm not going to repeat that. I'd like to take a little different tack, and I will just tell you that this is a very exciting time, especially for educators. When I first began coming to these FAA meetings, I would never have guessed that I would have a chance to serve on a panel, and this is my second panel in successive years, and I hope to get a chance to continue to do that.

Last week on Thursday, and Les, this should be near and dear to your heart, I had a chance to take the National Visiting Committee from our NSF Center to the launch of an Atlas IIAS from Complex 36 in Florida. I brought a prop to prove I was there. We had a great time at that launch, and that parking lot was filled with not only team members from the Atlas and the ILS people who were there from an international perspective, but also family members, children and wives and husbands of those workers. I think it was a very important demonstration of the kind of outreach that needs to happen if we are to continue to grow and do the things we need to do from a launch perspective. It was a great time, and I invite all of you to Florida to join us in those launch activities.

I'd like to acknowledge a colleague of mine, Dave Brotemarkle, who is sitting in the second row. Dave, would you raise your hand? Dave's a lieutenant colonel retired pilot. He flew *Looking Glass* some time ago. He and I are getting long in the tooth, and it becomes important for us to bring a message to you today about passing it on, and that's really what I want to talk about. He has copies of the latest newsletter from SpaceTEC. If you haven't picked up one of those, please go by and get one. He also has copies of these charts. There are six on a page. If you're not real young, you won't be able to read them. Even if you are real young, you might not be able to read them.

If you'll send me an e-mail, I will be glad to dispatch a PDF copy of that back to you. We've tested it, and it works. This is a very significant vehicle in my opinion. When I first got into this game a long, long time ago, there was a rocket plane called the X-15. Over the last 40 years the science had kind of diverged, where rocketry went in one direction and aviation went in another. Lo and behold, here we are in 2004 with a convergence coming back together. Now, I missed lunch yesterday. I understand that was Dr. Sega's theme. We didn't collaborate on that, but maybe some of these charts will underline some of the same points he made so well yesterday.

I want to talk about championing the aerospace technical workforce of the future, and I'm going to do it in three very quick steps. I'm going to give you a little bit of a summary from last year, review what we showed you there in those charts. Then I'm going to give you a very quick run-through of the current status of the SpaceTEC operation, and I'd like to wrap up with a review of what we think the future may hold. Next chart, please.

This is a program chart, which you saw before if you were here last year, beginning in the year 2000 and running out to the current time frame. The green boxes show all of the completed activities. You will note that we are on schedule and under-budget. We have developed the aerospace technician degree, secured funding from the State of Florida and at this point went national as we secured funding from the National Science Foundation. As I'll show you in the next chart, we continue to grow that operation. We currently have about 100 graduates from the program across the country at Brevard Community College where I am employed. We graduated 12 in December and 12 last May and most of those have already been hired into the industry, and thank God for that. If you want to kill a program in education, you graduate students that can't find jobs.

Over this next year, you will see that we roll out a national skill standards program. Now, let me just tweak your imagination for a minute because when we started this 3 years ago, people told us we were nuts. It is a fact that to work on an automobile in most shops in this country you must hold an Automotive Service Excellence credential. To work on a spacecraft in this country, you don't have to hold anything except what the company your work for says you have to hold.

We've been looking at ways to bring national skill standards to the table through the industry representatives, so that we can broaden the labor pool and standardize the talent and provide some mobility to the workforce. Today in this country, aerospace technicians have no professional career ladders, no organizations that front for them, no AIAA or IEEE, no journals, no conferences, no continuing education patterns. By the end of this year, you won't be able to say that because those are all beginning to roll out and will be in place. Next chart, please.

This is a very simple diagram of the goals of the National Center and, of course, the simple one is to be a national resource for aerospace technical education. I can tell you the SpaceTEC name is out there. We get calls every day and our problem now is to try to turn down – decide which things not to do because we are obviously resource limited. It ranges from everything from AS degrees, 2-year degrees in aerospace technology, to reaching down into the K-12 system to make that pipeline stronger as we bring students into the program. One of the things our industry counterparts told us pretty early in the game was, if you're going to do skill standards, don't produce a 1-year certificate. Produce a two-year degree so that when we hire the person, they can go on to a baccalaureate and master's degree and so on. Let's talk career – and that's what we've done. Next chart, please.

This is a map that depicts our partners. The red dots are the partnering schools. Over the last year, we have grown by 25 percent. We have added Antelope Valley College. We have added Thomas Nelson College, next to Langley. By the way, I'll say a little bit more on Antelope Valley. Keep in mind they're out at Mojave, and they've had a lot to do with the Scaled Composites guys already. We've added Embry Riddle, both at Florida and out at Prescott. Perhaps for us the ultimate compliment was in September when Embry Riddle came to us and said, "We really like what you're doing. Would you consider taking a 4-year university into your partnership of 2-year schools?" It took about 30 milliseconds for us to say, "Yeah, we'd like to do that."

I'll tell you that's been a marvelous decision because they've already rolled out articulation agreements, and we're beginning to bring to fruition a path that will allow technicians to move from 2-year to 4-year degrees seamlessly. Also, on this chart are depictions of some of the locations of our partners in what we call the National ATAC, the National Aerospace Technology Advisory Committee. I think on the next chart, if you'd go to that one, well, this is the local one. That's okay.

Essentially, at each of our schools, and there are 12 locations now in 10 states, we have committees like this. This happens to be the Florida ATAC. The Florida ATAC is, perhaps, the strongest and has been in existence now for almost 4 years, and you'll see that we have very powerful government partners, very powerful industry partners and a very broad spectrum of academic partners. That sort of mirrors what's taking place at each of those communities. Our colleges are typically adjacent to NASA or DOD facilities. The focus is very much on hands-on training for the technician of the future and on systems thinking for the technician of the future.

We all grew up in a time when there were electrical techs and mechanical techs and RF techs and instrumentation techs and you can't get there from here today, it's got to be much broader than that. Next chart, please.

The National Aerospace Technology Advisory Committee had its first meeting in August in Cleveland. This is the makeup of that group. I could spend an hour on this one because it's a very, very important group. If you're going to roll out a national program as a community college group, you've got to have national representation from the industry. On this group, we have five federal groups, four NASA centers, and they're listed there; and the FAA; Al Wassel, we're glad to have you on the team; Six aerospace state associations; five industry representatives, and this will probably grow to eight before the end of the spring; two non-profits, including the American Technical Education Association, I'll say more about that in a minute; and labor, the IAMAW. Next chart, please.

Now, this is another hour-long chart. I can't spend much time on it with you, but I will tell you that it's a very important chart because it depicts a national system that did not exist last year. It's a truly national system with the NATAC, those people I just showed you, the American Technical Education Association, which is a 76-year old organization for technical faculty at 2-year community colleges and technical schools, and a National Association of Aerospace Technicians.

The focal point is the community college partnership. The organizing focal point if you will, is SpaceTEC, and the depictions on here are lines that show fund flows and certification flows. I know every time I say the C word some of you in the audience flinch. We may not call it a certification, but we are very much aimed at National Skill Standards for Aerospace Technicians, and we will issue some kind of a certificate probably before the end of this year at two levels: a core level where an entry level technician from almost any area would need to have those skills and a concentration level, such as vehicle processing or manufacturing, aerospace manufacturing, depending on the school and the focus of the community in which that person lives. Next chart, please.

Just to show you that it's real, I suspect before the end of this year, we will have 1,000 students in the system rather than one or two hundred. These are pictures of, in this case, aerospace students at Brevard, working on a fluid system that they have put together as a training aid. It mimics the Shuttle fueling system for hydrazine. They built that from scratch, wrote the procedures, conducted the flow test, went through the failure modes, actually encountered a failure event that wasn't planned, and recovered from that. We, in my opinion, have graduated two of the finest classes of students that have ever gone out of a 2-year institution into the aerospace industry. We really see the importance of the hands-on work, and our industry partners are delighted so far with the product. Next chart, please.

These are some of those same students in the field. It's absolutely essential that we get access to the workplace. I would just remind you that over the last year, 2 years now, beginning with 9-11, huge setbacks because a lot of doors that were open to us closed after 9-11 because of security requirements. The loss of *Columbia*, the war in Iraq, a failing economy, a flat economy – those are not good things in the beginning of a start-up program for an aerospace degree. Somehow our students and our faculty and our staff have survived those things and come through with flying colors, and we're delighted to be able to tell you that it's working at this point. Next chart, please.

This is Pearl River Community College next to Stennis. You see they're doing work there in electronics. Next chart. Calhoun Community College, where they have a very large program in aerospace manufacturing. This is actually a section from the tank for a Delta 4, a very small section of a very large tank. Really neat stuff. If you get a chance to tour the Decatur plant at Boeing, do it. It will give you some idea of what manufacturing in the future for large-scale aerospace looks like. Next chart.

These are the graduates in December at Brevard Community College in Melbourne. This is Jim Kennedy. Some of you know Jim from his days at Marshall. He is now the Center Director at the Kennedy Space Center. It would be hard for me to tell you the enthusiasm of that group of students when Mr. Kennedy shook their hands as they came across the stage on December the 19th, received their degrees, and then afterwards met with him for photographs and autographs and discussions about where they would work. Students don't ever miss that opportunity. We have some really strong partners, and he certainly is one of them. You will see this program continue to grow, but it will not succeed without support from folks like you. That's my one unpaid advertisement. I want you to sign up and join the group. Next chart, please.

We had the very good fortune on November 7th of last year to be a part of a ribbon-cutting ceremony at the Cape Canaveral Air Force Station for the dedication of Complex 47, which is about a 15-year-old, meteorological rocket launch pad for suborbital work for education, and this is a picture of a Super Loki being prepared. Next chart, please.

We will be hosting teams to that site, I hope, from all over the country. You've seen this one many times. Our students from Antelope Valley College were invited into Scaled Composites, we believe as the first ever outside group invited to tour the facility. Burt Rutan is not exactly the most open guy in terms of sharing all his secrets, but he was so impressed with the composites work being done at Antelope Valley that he invited that group in. You can read about that in the newsletter as well. It's hard not to have a motivated group of students when you can put them in touch with people like Burt Rutan and Jim Kennedy on opposite sides of the country. Next chart, please.

Where is it headed? Well, one of the things we discovered, and this is a very complicated chart, I won't spend much time. This is the core, and you'll find yourselves in some piece of this if you're working in aerospace at all. We discovered pretty early in the game that there are not a lot of opportunities for launch technicians in this country. If you don't live in Florida or California, or maybe Virginia, you're going to have trouble finding a job. And we recognized – this little football chart ought to look like an iceberg. This is the 10 percent or less. The 90 percent are all these related technologies. Beginning last April, we broadened the net to say when we graduate technicians with skill sets that cross the board, they can work anywhere in this country in almost any industry.

For the future, you will see a broadening, without losing that kind of magic link to space because that's what intrigues and interests students in joining the program. The fact of the matter is there aren't very many launch sites, but every community in this country has a medical facility, a clinic, or a hospital where a technician can go to work as an instrument technician or whatever, so you're going to see much more in the related applied technology area. Next chart.

This is a feel for some of the endorsements that we have received already. I won't bore you by reading through them, but you will notice that we have some very powerful friends in the business. We do have Launch Complex 47 and now a lab and shop facility of almost 11,000 square feet, on site at Cape Canaveral Air Force Station. We are rolling those out as national education opportunities. All of our partners will have access to those facilities in one form or another. Hopefully, we'll begin to do clinics or exchanges of people.

We are very proud of our affiliation with FAA, and we hope to grow that. The National ATAC and the National Visiting Committee, get hold of those membership lists, and look at the kind of people involved. You will see that there are a lot of very important people who think that we need to be worried about the technical workforce of the future. Now, I'm a hardware guy like most of you in this room, and that's mostly what we've heard over this last day and a half. That's very, very important, but the fact of the matter is if you don't have a skilled workforce, it doesn't matter how good the technology is.

You need trained people who are proficient at what they do, and people graduating from our high schools in this country today are not very prepared for the work ethic or the basics in aerospace. This program moves them to where they need to be to be good entry-level employees. The companies will still need to take them to the next level of proficiency, but at least we've gotten a step up on the right process. Next chart.

Maybe this is the most important chart from our standpoint for the future. And if you can't read it, I do apologize. This says "aerospace" and this says "aviation." I'm not sure why this did this because on my copy it looks great. It's a Venn diagram, and it shows the overlap here where the technology convergence is taking place. As you know, maybe 10 years ago that was a little tiny sliver between the two great balls. Today, it's a much bigger piece of the pie. It will continue to grow, so we are looking at bridging programs so that A&P mechanics who want to move into the space arena have a path that they can come in and get training on. People from aerospace who decide they really want to do aviation, can do the reverse, that's why the linkage with Embry Riddle is so important. I think half of our 12 schools offer either aviation pilot training or A&P mechanic training, so it's kind of a natural anyway. We don't want to lose the focus on space, but we're smart enough to see this convergence beginning to emerge with many, many impacts including workforce skills, competencies impacts.

The technology for training methods and the facilities for training, we're out on the cutting edge for online, web-based training. However, we acknowledge the requirement for continuing hands-on work to qualify people to work on your rocket ship. You're sure not going to put people in there who don't have those hands-on capabilities. Next chart, please, and I think my final one.

Where are we headed? Well, if people listen to the President, we're headed to the Moon, Mars, and beyond, and I couldn't be happier. I was a part of the original NASA team that took us to the Moon, and I've been discouraged for the last 30 years that we haven't gone back. Maybe we will get a chance before I leave the Earth permanently to see that happen; I sure hope so. These are programs requiring interdisciplinary and multidisciplinary technical competencies, especially in small programs. We've heard from some really good entrepreneurs here. They can't afford an army of engineers and technicians. We've got to find a way to do it cheaper and better but without losing focus.

Formal requirements for certifications to work on space-related hardware. I don't know what the FAA role will be there, but I will tell you that my industry counterparts really would like to have the absolute minimum of government intervention. The ideal situation is an industry-based certification, self-regulation, if you will, very much like the Automotive Service Excellence Program, and we're headed down that path right now.

Finally, it is already past time for passing it on. Many of you have friends who have retired in the last 2 or 3 years. That will happen over the next 3 or 4 years. That 35- to 40-year database of expertise and experience is walking out the door every day in this country. We need to capture as much of that as we can. That's what SpaceTEC is all about. I invite you to join us in any way you would like; mentor, teacher.

If you have artifacts, send them to us, we need training aids. Get up on our website, http://www.SpaceTEC.org, and become a part of the team. Thank you.

(Applause)

MR. LARSEN: Thank you, Allan. Now, Mr. Jeff Spaulding.

MR. SPAULDING: Thank you. I am Jeff Spaulding. I am with NASA at Kennedy Space Center down in Florida, and I work in the Launch and Landing Office. Today I want to talk to you a little bit about a broad-brush approach to Shuttle operations and maintenance. I primarily work on the operations side, but I'll dabble a little bit on both sides and then talk a little bit about some of the things we do down there and how that pertains to maybe some RLV designs or some other considerations for RLVs of today and of the future. Next slide, please.

This is a large overview. If you kind of look in the shaded area in the middle here, these are the three main areas, here, here, and here. A Shuttle comes through, a lot of people in here I know worked with Shuttle or for Shuttle at one point or another. But after we land, we bring those Shuttles into the Orbiter processing facilities where we do our horizontal processing. Once we've completed that, we roll over to the Vehicle Assembly Building, where we do our vertical integration with our solid rocket boosters and our external tank. Once all of that is done, checked out, we roll out to the launch pad.

This particular slide shows some other things, for instance, off-line facilities here which we use to assist us in our processing here in the OPF. Our Thermal Protection System area, that's where we can create some of our tiles. We actually make some of the replacement tiles on the vehicle that need to be done, and we can do that in the facility here. There's a hypergolic maintenance facility where we work on our forward and aft reaction control systems which use hypergolics as propellants. If we needed to take those off for servicing or maintenance or inspections, we'll send them off to this area for that type of operations. Of course, payload work and horizontal integration come through here, and we have an engine shop, too, where we remove the engines that we would process at an off-line facility.

Over on the top side, after we've recovered our boosters out in the ocean, we bring them back, disassemble them, and send them off to Utah where they're reprocessed and sent back to us. We'll store them until we're ready to begin the stacking operation at the VAB [Vehicle Assembly Building], and that whole process starts over again. Next slide.

I'm going to talk about those three main areas: the Orbiter

Processing Facility, VAB, and our pad in a little bit more detail here. The Orbiter Processing Facility is really three bays. Of course, there are some office annexes there. One of our bays now is dedicated to orbiter maintenance full time. A vehicle will be pulled out of the flow to do that there. There's also an engine shop, as I mentioned, adjacent to one of the bays where we just do engine work.

Most of the major activities going on in our processing area, we do our post-flight de-servicing after we come back. The vehicle is still pretty hot, so we have to do some de-servicing. A lot of that is hazardous. Once we start doing our up-mission reloading here, we start working our subsystem checkouts, any tile inspections that we need to do, and repairs. We actually do a lot of inspections, but the repairs that may have been necessary after flight, and some of our flight readiness verifications and close-outs are done there. Payload removals and mid-body configuration.

I included these pictures just to show you the significant amount of hardware and platforms and all of the different structures needed to give us access to the vehicle. We almost have 360-degree access around the vehicle to work on it. We use all of that access for all the different inspection points and servicing points and all of those types of things and different stands that we've had to create in order to give us some better access to the vehicle.

Vehicle Assembly Building. A lot of people, I think, are familiar with that large building created in the Apollo era. There are four high bays in there. Two of them are integration bays where we do the stacking of the boosters and the tank and eventually the Shuttle. On the other side of the high bay, there are two other bays that we use primarily for external tank storage and then also checkout of those tanks before we go ahead and mate those. In addition, we can use them for a safe haven during our hurricane seasons. We need a safe haven if we have a vehicle at the pad, and there was a hurricane approaching. We could make the decision to roll back. We could roll it into one of those bays as a safe haven and also occasionally Orbiter storage when we need a place to slide an Orbiter into for a short period of time.

This is, of course, some other areas, some shops and labs in the Vehicle Assembly Building as well as remote manipulator systems. Some storage and checkouts of a robot arm that's on the Shuttle are done there. Most of the major activities, as you can guess, are preparing our mobile launcher for stack, solid rocket booster stacking like we see here, external tank integration of the boosters, and of course, finally the Shuttle, the third piece. Once it all comes together, we do a full-up systems test of all of those items before we're ready to roll to pad.

Our launch pads contain a fixed structure and then a rotating service structure. The rotating one gives us our best access up to the vehicle for the work and servicing we need to do at the pads. We also have a couple of different areas. We have our hypergolic storage areas where we have our fuel and oxidizer propellants and our cryogenic storage areas for liquid hydrogen and liquid oxygen. Those are all out of the pad area. Then we have all of the equipment and electrical and pneumatics and the supports that go along with all of that stuff.

Most of the major operations that we do out there, the first one we do is when we get out there, we plug everything in, and we see if it still works. That's our integrated vehicle checkout. Any payload work for installing station components, we do those generally out at the pad. That would be done off of this rotating service structure here, any of our final hydraulics system checkouts, ordnance installation and any of our final preps before we get ready for cryogenic loading during the launch countdown. Next slide.

We do have quite a bit of maintenance. I touched on this earlier, that we used one of our Orbiter processing facility bays just for maintenance. During that time, I'm going to take the vehicle out of flow. We call that Orbiter Maintenance Down Period or OMDP. Similar to large aircraft depot level inspections, we go through a complete inspection and recertification of the various areas, airframe, and systems. Generally, these are about every eight flights or 3 years. I think we're going to be looking at those numbers again and seeing how those are working out for us, but that's still kind of the baseline.

We go through all of these different types of inspections, whether they're routine structural, time and cycle changes, special ones for wiring, and those types of things. Next chart, please.

While we're doing these OMDPs, we also found that there's a need to do some major modifications to the vehicles at that time. Some of the examples are when we moved the air lock from the inside of the vehicle to the outside so that we could mate to the station and those types of things. There are a lot of modifications that are done on a vehicle that are major modifications. Those would be done during these OMDP periods as well. The modifications that we do are generally there for safety, performance, processing, aging fleet issues, correct stumble-ons. Stumble-ons are things that we may find during the normal course of processing.

For example, we may have wire bundles that are in high traffic areas that we want to move out of the place, and we'll do that during these periods. Now, I'm going to fold that into some RLV considerations for some of the other stuff and a broad picture that we do with the Shuttle. Next slide, please.

Landing and turnaround, this is one of those things that sometimes doesn't get as much thought when we're going into the launch. The launch tends to get most of the focus, but as you're designing RLVs you have to consider where you're going to land and how you're going to do it. The Shuttle, of course, lands a lot like an aircraft. Although it's going a little over 200 knots when it lands, it lands on a conventional but longer runway. We do have a convoy that meets it and we hook up out on the runway for purge and electrical and cooling and also to de-stow any time critical items. We have a whole bunch of people that do all that as well as some initial inspections and getting the crew off.

Of course, if we land out in California, we have to fly it back on a converted 747. Then we have the specialized device here to de-mate the 747 and Orbiter and which we use to take it off of that aircraft, so all of that is planned out in advance. Knowing where our landing sites are at, those are some considerations. Also water versus land, are you going to land on the water or land, runways versus parachutes. All of those different things come into the complexity of your landing considerations. Range safety destruct systems, those are more on the launch side than on the landing, but those are also considerations for vehicle design.

Population overflight, I think we heard a little bit about that in some of the presentations and some of those concerns as to where you pick your launch and/or landing sites. Obviously, after the *Columbia* accident, that's getting a lot more attention now as well.

Ground guidance and tracking systems are very important, so you know where your vehicle is at all times, especially if it goes off course.

Emergency landing sites, again, that kind of feeds back into that. Are you going to have emergency landing sites, and if so, how do you maintain those? Then once the vehicle comes down, how do you get it back? We were talking this morning, we may have some recoverable parts that are going out into the ocean. How do you get those back? There's a lot of consideration that has to go into that. You don't just necessarily go out and pick them up. There's a lot of processing that goes along with that. Next slide, please.

Hazardous operations and egress systems, these are always big considerations during our processing. When we're working on hazardous systems, there are a lot of clearances involved. The hazards associated with those make it difficult for processing. A lot of times during systems design, when we're coming up with trying to maximize performance of our vehicles, we don't always consider the operations side of it and/or the handling and transporting. It's very important to do that because that can really drive up costs and hurt your safety as well in trying to deal with those hazardous systems.

We've been doing assessments. We have auxiliary power units that we use to drive our hydraulic systems, and those contain hydrazine. We've been looking for a number of years at trying to use electric ones versus the ones that use hydrazine, just due to the hazards with trying to service those and potentials for leaks and those kinds of things. If you're going to have hazardous systems, you have to figure this out in advance, how you're going to handle them, store them, transport them, do the servicing and everything, as well as having detection and monitoring systems either on the ground or in flight.

You also have to address environmental issues. We heard quite a bit about that yesterday. We're in the middle of a national wildlife refuge at

KSC, so we have to be very good environmental stewards. We always have to consider that for all of the work we're doing, especially with all the hazardous commodities that we're dealing with. When you have humans in the system, especially if it's a human rated vehicle, you have to have escape systems. Here you see the astronauts doing one of their training sessions at the pad when they've gotten out of the vehicle and going down the slide wire basket to get to a safe area. Vehicle escape systems, both on ground or in flight, and those things are big considerations. Next slide, please.

Thermal protection systems, this becomes crucial for vehicles that are going to be orbital vehicles coming in on re-entry. How do you do that? The Shuttle has a fairly complicated system. We have 25,000-plus tiles on the Shuttle, and those are really manual labor intensive to put on the vehicle. Each one is pretty unique based on where it's at and the heating that it sees. There's a lot of manual labor that goes into just installing one tile. New systems try to be more robust, have as little manual inspection as possible. Ease of repair is essential and critical.

No waterproofing; we waterproof these tiles every single mission because they're fairly porous. They absorb water very readily, so we have to do that as part of our normal routine. It's very labor intensive to do that. The guys down here in the corner with these heat lamps, this is a vehicle that came back from California, got doused in some rainstorms, and absorbed a lot of water. We're trying to dry that water out using those heat lamps and a makeshift system that we had there. As I mentioned earlier, we do have a replacement tile facility where we would make some replacement tiles as needed. Next slide.

Off-line maintenance, do you process the vehicle all intact, or do you take parts and components off, engines, other components? On the Shuttle, we remove our OMS pods and our FRCS, which is our reaction control systems on both ends, send them off to another facility. Sometimes when you do stuff like that, you duplicate your resources, and some of the things that you do in multiples of your facilities as well. If you don't have to do that, maybe you don't want to, or maybe there are other overriding reasons that you do. Those are all the considerations that make it a little bit more challenging. In the middle frame, there you see we're pulling out one of the engines there in the OPF. We have a special piece of equipment just to do that.

Ground support equipment, these are often the last things to be thought of. How are you going to service the vehicle? How are you going to inspect it? How are you going to do the different things that need to be done during that process to turn it around, especially if you have short turnaround cycles? Is it going to be all autonomous? How much human interaction do you need? What you're seeing here, we're pulling off one of those pods, and there's a lot of people involved, specialized equipment, cranes, lifting operations. It makes for a big operation, and it's very difficult.

The fewer hazards you have make it easier on some of these systems. Clean gas systems are a lot better than some of the hazardous systems you have to deal with. We have to clear our entire launch pad when we're servicing our pods. Commonality between the commodities is a good thing too if you can do that so that you don't have multiple fluids that you have to worry about for the vehicle. Some of the other considerations down at the bottom. Maintenance on those systems, hazardous ones, is going to give you more headaches than some of the other ones. Weather, if you're going to be outside.

Our launch pads are outside. We have lightning considerations. We have winds, hail, a lot of things you have to deal with as well as the fact that we're by the ocean. We have a corrosive environment that we're dealing with continuously, so all of those things are important as well as noise.

And the last slide, questions are going to be at the end, but really that's all I had. I just wanted to say, the Shuttle itself has been the workhorse of the human space flight side for 20 plus years now. Even with the drawbacks on it, it's still a marvelously technologically advanced vehicle. Still it's very complex. With that come a lot of operations and maintenance challenges that we've been addressing throughout the years and will continue to address as we return to flight. Hopefully, those challenges have also provided some lessons for many of the people that are here and some of the future designs and future stuff that's going to be going on as well. That's all I have, thank you.

(Applause)

MR. LARSEN: Thank you, Jeff. And now Les Kovacs.

MR. KOVACS: Good morning, everyone. I was sitting in the back during the previous panel, and I heard that question about spousal concurrence for suborbital flights. I can tell you that if I was doing that, and my wife was with me, she'd say, "Of course Les can go and do a suborbital space dive. In fact, honey, let me pay for this one."

(Laughter)

Let me give you a quick story. When I was a launch controller at Atlas, we were launching an Atlas IIA. About 2 to 3 hours before T-zero liftoff, we have airborne security circling the launch complex. We make sure that civilians and people are out of the hazard area. We establish a fallback position.

All the emergency vehicles are there waiting and stuff. We seal the blockhouse doors, and airborne security is monitoring the whole launch complex.

Well, airborne security radioed down and said, "Hey, we're getting an infrared hit off of a vehicle in your parking lot," which is about a tenth of a mile away from the launch complex. It's very close. You don't want to be there when the vehicle takes off, so we said, "Well, we've had that fallback position already established for 3 hours." We have no idea what that is, so we asked security to come in and take a look at the parking lot. Security drives in. They get out of their vehicle, and the guy walks around to the front. He feels the front hood of the car, and he's like, "Well, the hood is cold, so it's been here for a while. The infrared cannot be coming off the hood of the vehicle."

He walks around to the back end, grabs the trunk lid, and opens it, and there's a guy in there. He's trying to get close to that launch and watch it through a crack between the bed of his trunk and the trunk lid. The point of that story is that space is fascinating, and people want to get close to it. People want to participate. It is a neat thing. If you were around in the days of Apollo and you watched people stepping on the Moon, people cannot get enough of space. I want to thank the FAA and Patti and George for hosting this because this is one of those critical steps to getting people involved, the taxpayer involved. That's where this will eventually progress to, getting the taxpayer involved and getting them energized and excited about space again. For the record, we did remove the guy from the trunk, and he wasn't there for the launch.

All right, this briefing is not in your packages, so take note of the Internet address there, e-mail address, sorry, and I will be thrilled to e-mail you this presentation. All right, next slide.

This presentation talks a little bit about some general philosophizing when it comes to operations and maintenance, and I'm going to give you some general things that we have observed at Orbital in the last 5 or 6 years when it comes to operations and maintenance or reusable launch vehicles. Then I'm going to give you some specific examples which indicate that to make improvements in operations and maintenance, there's a cultural problem out there. It's not a technological one. A lot of people seem to think that you need better materials, and you need different types of processes. Some of that is very true, but there's also a cultural perception problem on how maintenance is performed on launch vehicles, and I'll point that out as we go on.

This slide here, the bottom left-hand corner, X-34 is the advanced technology demonstrator. It was supposed to demonstrate small crew sizes, rapid turnaround of the launch vehicle, 200,000 feet, Mach 8. The program was canceled about 2 to 3 months before we dropped the vehicle unpowered for the first time. The top right, a couple of years ago there was a program to not exactly replace the shuttle but to get a next generation launch vehicle built to ferry people back and forth from the International Space Station. We participated in that effort. That was known as the second-generation reusable launch vehicle, 2GRLV. At the top left, that 2GRLV system sort of morphed into this space taxi crew transfer vehicle. That's what you see right there. It's sort of a takeoff of, for those of you who follow this type of stuff, the Russian HL-20 lifting body vehicle that flew in the 1980's. Most recently, the Orbital Space Plane Program, which used that space taxi crew transfer vehicle as a baseline concept (the plane part of Orbital Space Plane should have been Orbital Space Capsule), and that's what's at the bottom right.

All indications are that for crew survivability the next vehicle needs to be a capsule, for the reasons that Jeff pointed out. The thermal protection system is very complicated on the Shuttle. One of the ways to simplify that is to just put an integral heat shield on the back of the capsule. Okay, next slide.

Here's what I'll talk about today. Because I'm talking about operations and maintenance, I want to speak a little bit about the labor that goes into building and integrating a launch vehicle. There are a couple of trend lines there that govern what that level of labor will be, so it would logically follow that I should tell you what we need to do to get below the trend line and improve that. Then I'll give you some examples of operability and maintainability and some comments on where I think we need to go from here. Okay?

Labor intensity in launch vehicles is measured by a metric known as maintenance man-hours per flight per pound of an un-fueled vehicle. I'm going to give you some examples of that. Generally speaking, that varies in the launch world anywhere from -- it's actually more like 40 maintenance man-hours per pound down to 1 maintenance man-hour per pound. However, if you throw into the mix the air-breathing vehicles, fighters, Air Force fighters, tankers, aircraft, then it's a five order of magnitude difference. Launching a rocket is not the same as launching an AmericaWest flight from the end of a runway. Those are two different animals. There are a lot of folks out there who seem to think that if you incorporate aircraft thinking into the rocket world, all of a sudden the business becomes easier. It's just not the way it's done.

Like someone on the previous panel mentioned, space today is about at the 1910 point for where we were with aircraft. We're nowhere near normalizing operations in the launch vehicle business. All right, next slide.

If you get anything out of this, pay attention to this slide. When I e-mail you the package, print this thing out, study it, become one with it. It's not quite a mystic experience, but it's pretty close. The blue line is the sonic trend line, so if you look at the horizontal axis there, those -- it represents the weights of the vehicles un-fueled. Their location on the chart is the amount of labor that goes into that vehicle per pound. You can tell that if you scan up to the red line, launch vehicles have a much greater labor intensity than the air-breathing vehicles. For all the bashing that people do of the Space Shuttle over here, the space shuttle is actually one of the best vehicles for labor intensity. They expend about 1 hour per un-fueled pound of that vehicle in labor to turn it around. That is awesome.

Conversely, you'll see that the Atlas and the Delta up there, they're roughly 10 times worse. They're 10 hours per pound. If you look down here to X-15 and DC-X, this is a very important metric, the relationship between those two. X-15 flew approximately 200 missions. It is probably the most operational vehicle we ever had, hypersonic, 200 missions, labor intensity between one-tenth and one hour per pound.

DC-X flew, and its labor intensity was only three times better than X-15, and that's after a 40-year period of technological advance. It's a leap of faith to give DC-X that much credit because it flew at about Mach 0.5. The X-15 was hypersonic, so if you look at general labor intensity, it's two different worlds. You cannot equate the two. You can say that moving up the left side, the faster a vehicle goes, the more labor you're going to expend on it to maintain it because chances are it's much more complicated than a slower vehicle. The heavier the vehicle is, you're obviously going to expend more labor. Next slide.

The clustering along those trend lines tells us that chart is valid because it's approximately invariant with the dry mass for a vehicle type. There are different classes of vehicles. You noticed on the chart that all the fighter aircraft were clustered on the bottom left corner of that chart. They all have relatively the same labor intensity. The Space Shuttle is not expensive because you have an unproductive workforce or because it's a complicated vehicle. It's expensive because it's big. It's really big. It's basically that simple. There is a direct correlation between the weight of a vehicle and the amount of labor you throw at it.

The take-away chart here or the take-away portion, the yellow is what I was telling you about earlier. That is 40 years of technological advance, and DC-X was only a factor of three improvement over X-15. It suggests that DC-X may have demonstrated to us that that is the limit of chemical rocket technology today. Turning around a vehicle with a chemical engine, this is probably about as fast as we can get. Now the Atlas V and the Delta IV vehicles, we don't have enough data to make a call on that yet. We suspect that those vehicles have labor intensities below the trend line that you saw for space vehicles, so they are an improvement. We are moving to the bottom of those. All right. Next slide.

How do we get below the line and make this more cost efficient for operations? How do we move the numbers down below that red line for orbital, reusable, and expendable launch vehicles? So far, the focus has been on structural materials, carbon fiber. You know, composite tanks, improvements to structures, and different propellant compounds to increase specific impulse, so the engineering solution is to look at that.

There is not a lot you can do in operations and maintenance to increase that mass fraction. Anything you do to help me out to work on that rocket is going to cost you pounds of payload to orbit. If I ask you to put a door on the side of the rocket, so I can access the flight computer, you're going to put a door there. Then that effort alone is going to cost you weight because when the door is not on the rocket, you're going to have to reinforce the opening, and that costs weight. You may as well just subtract that directly from the payload to orbit. It's essentially that simple.

In operability and maintenance, the things that I think we can do which would be of benefit, and somebody mentioned it before, is integrated vehicle health monitoring and integrated ground health monitoring. Automated systems to tell me what's broke, so I don't have to climb into an inter-stage and start tearing things apart, or you don't have to go into the Shuttle's engine bay and start taking things off the wall to try to figure out what's wrong. TPS improvements, we already talked about that. There are TUFI tiles. These are new thermal protection system tiles which are very good. They're mounted in the Space Shuttle, back where the engine is, a pretty violent environment. You get a lot of air recirculating back there, a lot of potential for damage. After eight flights they looked brand new. One of the steps would be to try to use those on the windward side of the launch vehicle. We don't want landing gear coming through any place where there's a tile, so hot-side penetrations need to be minimized. If you're going to put equipment in the rocket, don't bury one component under a layer of other components. If something goes wrong back there, you need to remove that to get to the layer where you have a problem. That's a huge difficulty in the Shuttle. You're violating the integrity of systems to get at some other systems that require maintenance.

Aircraft-like logistics support, that is valid. That's just essentially innovations in ordering replacement parts and then a robust structure for damage tolerance. This essentially means if you need a quarter inch bolt, maybe you should use a three-eighths inch bolt. It makes the vehicle a little more robust. The problem is that you're paying the weight penalty that I talked about earlier. Okay, next slide.

This is an example of some maintainability examples. On X-34, we replaced about 20 feed lines with this flange here called an AS-1895 flange. It replaced this here. The customer said, "You can't do that; it's not going to be strong enough," so we went and took it to the lab and tested it. In all measures of testing, it was stronger. Then the customer said, "Okay, fine, it may be stronger, but it's going to leak like a sieve." We went back to the lab, ran gaseous helium through it, which should leak, and it performed even better on that.

There's a mentality -- that's what I was trying to get at earlier, there's a mentality associated with introducing new concepts. For those 20 joints that we replaced like that, it saved us 6 pounds. Six and a half pounds per joint, that's not trivial. Then the other thing that we learned from X-15 was X-15 mounted a whole bunch of stuff on a rack. If you needed to get to the rack, you opened a door, and you pulled the whole rack out. Instead of unscrewing fittings and things to just get out one piece, you pulled the whole rack out and replaced it with a new rack. Then you took that rack and performed maintenance on it. That's a critical improvement to launch vehicles and reusables. Just do the wholesale replacement. Next slide.

These are some operability examples. This is some recent work. I ran out of time here. To make a vehicle maintainable, the heat shield -- this is actually a propulsion module on the back of this capsule. Right here, that line is the separation plane, so when the propulsion module drops away, you've got this nice heat shield. That integral heat shield means that you don't have 25,000 tiles, so you can just remove the entire heat shield and expose all the systems beneath it that need repair. That was an operability improvement.

We also incorporated integrated vehicle health monitoring which would tell us, "Look, this component is broke, or this component looks like it's going to break, and you need to replace it right now." It not only had a diagnostic capability, it had a prognostic capability. Okay, next slide.

To summarize, rockets are not airline type operations. The risk of screwing up in the rocket business is that somebody ends up dead. If you have an engine that flames out on an aircraft, you land at the nearest airport. Everybody goes home, or they get put up in hotels, and they fly home the next day on some different flight.

In the rocket world, someone is dead. The environments are much harsher. An aircraft travels 2,000 feet per second. An orbital vehicle is about 15,000 feet per second. An aircraft is not going to see the heating rates that a capsule does when it's re-entering. It's a very high-risk activity. You get a burn-through on a thermal protection system, somebody is dead. Puncture of the pressure vessel on an aircraft, it's going to be unpleasant; on a rocket, you're dead.

These, though, are the things that I think you can do. The first is talk to the people who operate the vehicle. They're going to give you some desires that they would like implemented into the design. That's one of the things that we're doing at Orbital on the Orbital Space Plane. I, as the operations and maintenance guy, go and talk the engineers when they're sitting there at their graphics workstations designing vehicles. I tell them, "Look, I'd like a door here. Can I have one there without tripping you up? Can you set up the vehicle in such a way so that when it's sitting at the pad, I don't have to have an umbilical arm that wraps around it? I need an access door here, or a vent here, or a fueling or an electrical line here and here.

The operations guys need to talk to the designers. Space Shuttle main engines are supposed to be good for 25 flights. After every flight, we take them out, and we rip them apart, and we look at them. Why? Because it's a high-risk activity. We need to feel good about ourselves. We need to reassure ourselves that, okay, it's supposed to be good for 25 flights, and this is only flight three, but I need to convince myself just to make sure that it's really still good. What I'm suggesting is we need to take the word of integrated vehicle health monitoring to some degree to try to get away from that. If you're going to design it and spend the money to make it robust, then treat it as if it were robust.

Now, that's a very simple way to look at it. That answer's probably a lot more complicated because you may miss a hairline.– you're not going to detect a hairline crack with IVHM, so the jury is still out on the extent of what you can do there.

Abandon this rapid turnaround philosophy that we have. We seem to think that we need to turn these rockets around as fast as we do aircraft. I have heard briefings where people say, "We're going to turn this rocket around in 72 hours." You can't even convene a meeting at Kennedy in 72 hours. It's not realistic, and it hurts credibility. It needs to be realistic. The fastest I have seen is about 480 hours for a simple bare bones vehicle.

I was asked, what can the FAA do to standardize the range approaches, not necessarily make them law because the launch vehicle operators like the idea of being able to tailor their activities to 127.1. It doesn't need to be a law. We prefer the tailoring approach. That's it.

(Applause)

MR. LARSEN: Thanks very much. Thank you very much, Les. We have some time for questions. I know we ran a little over, say 5 minutes. Okay. Do we have questions from the audience? There's a question.

AUDIENCE MEMBER: This question is for Les Kovacs. I was just curious as to whether or not the maintenance man-hours per pound criterion is necessarily a good one. I understand that there is some correlation between vehicle complexity and size, but is that one that really bears out over time?

MR. KOVACS: It has. We have subcontracted that analysis, and we're getting that data direct from the manufacturers of those vehicles. So, yes, it does correlate out over time. What the chart doesn't talk to, though, is the price of that labor. For an Ariane 4, the labor equates to about $220.00 per pound for an Ariane 4 launch vehicle. In the United States that same level of labor is about $65.00 a pound across all the launch vehicle manufacturers. An Ariane 4 looked good on the chart; however, it is three to four times more expensive.

MR. LARSEN: Right here.

MS. BRECHER: Ever since Henry Ford invented the conveyor belt for rapid manufacturing and in the computer age, where we have plug-and-play components, you pull out a mother board and you put in a new component, why can't we design that kind of approach in modular parts that fit together and can quickly be replaced for RLVs at least? I mean, we are approaching this in the airline industry.

I've been to the Boeing factory in Everett, Washington, and it's amazing how quickly they can put together an aircraft with parts that come in from 145 countries. Why can't we adopt that kind of approach to simplify a rocket? I understand that maybe for many Deltas and many Atlases and many generations and if we use strap-on approach we might actually simplify maintenance and assembling a vehicle quickly.

MR. SPAULDING: I think that's always the goal, at least nowadays it is. Certainly in the Shuttle world, we're still working a vehicle that's a 30-year old design. Even with those older designs, we are continuously improving it, upgrading it, making it more modern equipment. Computer equipment, built-in test equipment, IVHM we're talking here, trying to make the systems more reliable, more durable, more detectable and all of those types of things. I think it's an excellent goal, and it's one of the things that comes out of this conference is to build that kind of stuff into your vehicles as you're coming along to make them more modular and more self-sufficient. That's the only way, I think, that we can attain the turnaround rates to make these things profitable, to make them more worthy of the type of things that we're talking here today.

MR. LARSEN: Anybody else have a comment on that?

AUDIENCE MEMBER: One for Mr. Spaulding.

MR. LARSEN: I was just going to add to what Jeff said. I think what Les was saying, it's key to get the operations people into the design at first. That's the way you're going to get efficient operations, things like what the

X-15 did, this rack that Les brought out. It's much more efficient to take that out than undoing screws and all. There's a lot of ideas where we can get the turnaround more efficient and still accomplish what you need to do, but you've got to do it up front, and then you've got to test. You've got to do some engineering, build models. That may be a little more expense at first, but over the life cycle cost, you're going to cut things down and get innovative people and their thinking. Brainstorm things, just don't do a point solution. Look at all the alternatives, those are the things that I think can help you get the turnaround times down.

MR. KOVACS: In the past, racks were frowned upon. Palletized components were not looked at favorably because they were metal racks, or they were metal pallets, metal platforms. On the X-34, we went the composite route. Now the pallet weighs a heck of a lot less, and there's not a compelling argument not to put a pallet on there. We took families of valves, pressurant valves, propulsion valves, and we put them on a single pallet, used that flange-type interface. It was easily removable in less than an hour, so, yes, the industry is going that way.

MR. LARSEN: I think we can take one or two more questions. Jeff, oh, I'm sorry, Brian, go ahead.

AUDIENCE MEMBER: Yes. for Mr. Spaulding: I was just curious to know from an operations manager's perspective, if you ruled the world what would be a comfortable STS turnaround rate or launch rate?

MR. SPAULDING: Well, I think that right now, and certainly, in light of the accident, there's a lot that we're doing out there to try to get back to where we can get to return to flight. It's difficult to say that we're going to change or improve where we've been in the past when we're doing more stuff now than we had previously. There's a lot of changes that we're doing now which are actually going to probably drive up our turnaround rates for the near term. In order to drive them down, we've been doing a lot of stuff in the past and will continue to do so, improvements in equipment processing and turnaround operations, but it's hard – I really can't quantify a number or a time frame – because we're still in a state right now where we're defining some of the requirements for our return to flight actions.

MR. LARSEN: Okay, one last question from Jeff Greason.

MR. GREASON: This is more of a comment than a question. First off, great presentations. It's really great to see O&M issues get some of the attention that they deserve. I particularly want to congratulate Mr. Kovacs because that's very similar to the analysis that we did when we sat down to start XCOR. That's the reason we're in the engine business – we looked at that same thing and said, "If we don't do something fundamental, there's no way we're going to make money at this," and FYI, we're running at about 0.01 on your metric right now.

MR. LARSEN: I'd like to thank our panel for the very insightful presentations. I think it gives us all a lot of food for thought. The next session will start at 1:15. We'll get in a little bit early, so we still have about an hour, I think, by my clock for lunch. The cafe here, I had breakfast this morning, it's excellent. A little pricey but, you know, it doesn't take much to go there and get a bite to eat. There are some restaurants right close also. Thank you very much for your attention.

(Whereupon at 12:13 p.m. a luncheon recess was taken.)

AFTERNOON SESSION

(1:20 p.m.)

MS. McARTHUR: Everyone, could we please be seated? We're getting ready to start again, please. Everyone please be seated. Okay, I hope everyone enjoyed lunch. Now we're getting ready for our final panel of the day, The Future of Commercial Space Transportation, The Next Twenty + Years. Our panel moderator is Stewart Jackson.

Stewart has over 26 years of experience in the aerospace industry. He started his career working for RCA Space Center in Princeton, New Jersey, where he led programs involved in spacecraft design, integration and test, systems analysis, systems engineering and robotics and space servicing. He moved on to Fairchild Space Center in Germantown, Maryland, where he led an engineering team to develop a spacecraft berthing device for use on the Space Shuttle.

Later Stewart accepted an opportunity to work for Matra-Marconi-Space in Toulouse, France, where he spent nearly 2 years working on various spacecraft analyses and designs. In 1994, he joined the Office of Commercial Space Transportation. Stewart has led teams in a number of AST firsts, such as granting the first launch license that included re-entry of a re-entry vehicle, launch site operator's license, international inspection, and development of the reusable launch vehicle regulations. He is presently AST's Deputy Division Manager for Systems Engineering and Training. Stewart holds a Bachelor of Mechanical Engineering from the City University of New York and an MBA from Strayer University. He is also an AIAA Associate Fellow. And now it's my pleasure to introduce Stewart Jackson.

(Applause)

MR. JACKSON: Thank you, Camilla. Good afternoon, everybody. I know it's sometimes tough to re-start the conference after a nice lunch, but you know, the thing about taking a lunch at the conference for this particular panel is that this panel deals with the future. When you think about the future, you have to dream, so I think it will be okay for some people to dream a bit now – with their eyes open, please.

I'm quite excited about being here and being a moderator for such a distinguished panel, especially because of the fact that things usually excite me a lot. I get very engrossed in history and very excited about the future. It's probably because the future is a mixture of all, meaning that you've got to have your past; you've got to have the present in order to even think about what the possibilities are in the future.

When I first thought about this panel, it led me to thinking about my 81-year old father. As a teenager, what were his thoughts, or what inspired him to think about what space travel would be? My father's vision was probably inspired by Buck Rogers, the movies with ray guns, anti-gravity belts, rocket ships that produced plumes that always seemed to be at a right angle to the trajectory. Yet, the rocket ship still goes straight.

(Laughter)

The thing about that movie was that there were many futuristic items that are now a reality. For example, lasers, rocket ships, and jetpacks, so there's something to be said about the future or thinking about the future at my father's age. For myself, when I was a teenager, my dreams were inspired by NASA, Apollo, Moon mission, 2001: A Space Odyssey, and Barbarbella.

(Laughter)

As everyone knows, it's a campy space movie that I believe Jane Fonda would very much like to forget about, and Star Trek.

Since then we have landed on the Moon, and we are traveling in space, so I guess some of my dreams have also come true. As for my teenage daughter, her visions of the future space industry may very well be inspired by the topics this panel will discuss today. If her dreams follow a path similar to my father's and mine, then those can become true in reality as well. I hope that this panel can inspire or stimulate the possibilities. I believe we can do that based on the five topics that we're going to discuss today.

One, the future infrastructure. This panel will try to address the type of spaceports and ranges that may be required in the next 20 plus years. Two, the future technology of launch vehicles. The panel will try to provide a cursory look ahead at the key launch vehicle technologies that will take advantage of the future infrastructure; and finally number three, which would be the future entrepreneur. Now, I know people will say that if I had a magic ball or something I could put in my hand I would be rich, and I wouldn't be in front of you guys here. I'd be with Bill Gates, but this panel will try to discuss some of the possible investment avenues for the aerospace industry in the next 20 plus years. Then fourth, future space policy, the panel will try to answer how space policy would change, and the end benefit to industry in the next 20 years. Finally, the public perspective. What will the public expect in the next 20 years? Looking at that, with the insight this panel can bring forward for the future of commercial space transportation, I think that this panel may have some grounds to help the FAA and today's industry to chart a profitable, productive, and exciting future, and I'm looking forward to this future.

So without any further ado, I would like to introduce the panel members. First of all I'd like to start out with James Heald. James Heald is the Director of the Space Engineering and Technology at Kennedy Space Center. He is responsible for leading the Center's efforts for integrating engineering and space technology development. Also, Mr. Heald leads KSC's spaceport engineering and technology organization efforts.

Prior to joining NASA, Mr. Heald served 26 years in the U.S. Air Force. His most recent assignment was as Vice Commander of the Air Force Research Laboratory, Wright-Patterson Air Force Base. There he played a key role in directing the Air Force science and technology program. He is a distinguished graduate of the Air Force Test Pilot School, a distinguished graduate of the Air Force Command and Staff College at Maxwell Air Force Base, and an outstanding graduate of the Air War College.

Heald is rated a master navigator and has logged over 2300 hours of flying time in more than 30 different types of aircraft. He serves as a Director for Student Training and U.S. Air Force Test Pilot School at Edwards Air Force Base. Prior to assignment to Wright-Patterson Air Force Base in Ohio, he served as Commander of the 46th Operational Group, Air Force Development Test Center at Eglin Air Force Base in Florida. Mr. Heald has a Bachelor's Degree in Computer Science and Mathematics from the U.S. Air Force Academy and a Masters Degree in Computer Science from the University of California in Florida. Jim Heald will be addressing the future infrastructure.

Let me go on to Carey McClesky. Carey McClesky currently serves as a Technical Manager in the System Internet Office of NASA KSC, Spaceport Engineering and Technology Directorate. He is active in advanced space transportation concepts and technology. Mr. McClesky has been at Kennedy Space Center for 25 years of its 41-year history. His career began in 1978 as an aerospace engineer, college co-op student trainee.

After several assignments, he graduated in 1983 with a Bachelor's Degree from Georgia Institute of Technology. Following graduation, he converted to a full time KSC employee. He has served both technical, supervisory, and management roles as a member of the Space Shuttle team throughout 1999. He's a senior member of the AIAA and has earned several group achievement awards and NASA's "Snoopy" Award for work performed following the *Challenger* accident. Mr. McClesky will be addressing the future of technology in launch vehicles.

Tim Huddleston. Tim is the Executive Director of the Aerospace States Association, ASA, and the ASA is the national premier organization representing the U.S. states in matters of aerospace policy with State Executive Branch appointed delegates representing each member state. In addition to his ASA role, Tim serves as the Center Director of the Aerospace Development Center, ADC, in Alabama. ADC is a state program charged with the responsibility of advancing aerospace research, commerce, workforce development, and education throughout Alabama.

Previously Tim Huddleston served in Alabama as the Governor's Advisor for Aerospace Affairs and Senior Space Policy Advisor. In this post, Tim reported to and advised the governor in matters related to aviation and space policy and industry development in Alabama. Tim served on the Alabama Commission on Aerospace Science and Industry as the Governor's designated representative. He also served as a Commissioner on both the Government Task Force on Military Affairs and the Alabama Commerce Commission. Tim has been elected twice to the post of the Chairman of the National Coalition of Spaceport States and completes his final term in February 2004.

Tim has written a number of works on space policy and space development and is considered to be among the leading authorities in space infrastructure development. He has received numerous awards and honors for his work. Tim is a native Alabamian, you couldn't fool me, and graduated from the University of Alabama with a BS in Aeronautics. Tim's presentation will address future entrepreneurship.

Edward Hudgins. Edwards Hudgins is the Washington Director for the Objectivist Center, and was formerly a Director of Regulatory Studies at the Cato Institute and editor of a regulations magazine. He is an expert on the regulations of space and transportation, pharmaceuticals, and labor. Hudgins serves as a Senior Economist for the Joint Economic Committee of the U.S. Congress and was both Deputy Director of Economic Policy Studies and Director of the Center of International Economic Growth at the Heritage Foundation.

He has testified on many occasions before the Congress. His opinions and writings have been published in the Wall Street Journal, the Hudson Chronicle, U.S.A. Today, Philadelphia Inquirer, The Journal of Commerce, and Aviation Week and Space Technology. Mr. Hudgins is the author of *Freedom of Trade: Refuting the New Protectionism* and *Space, the Freedom Market Frontier*. He has appeared on NBC Dateline news, National Public Radio, PBS, Fox News Channel, CNN, MSNBC and Voice of America.

Hudgins has a Bachelor's Degree from the University of Maryland, a Masters from The American University, and a Doctorate from Catholic University, and he has taught at many universities in the United States and in Germany. Dr. Edward Hudgins will be addressing future space policy.

Last is Joan Horvath. Joan is CEO of Takeoff Technologies, LLC, in Southern California. It's a Southern California-based technology strategy consulting firm that is working to encourage various emerging sectors of the aerospace industry to work together. She is also an Executive Director and Co-founder of the Global Space League, Incorporated, based in Frederick, Oklahoma, and that is a 501(c)(3) non-profit that takes middle and high school science experiments along on expeditions to extreme environments. They're hoping one day to be able to take their experiments into space.

Prior to becoming an entrepreneur, she completed 16 years of engineering, spacecraft flight operations, and program development positions with Cal Tech's Jet Propulsion Laboratory. She holds engineering degrees from MIT and UCLA and also teaches graduate courses at the University of Phoenix. Joan will be presenting the public perspective.

Now, let me have Jim Heald come up and give his presentation. Thank you.

(Applause)

MR. HEALD: Well, good afternoon. I want to follow on with what Stewart's theme was here a little bit and have you imagine a little bit. Dream a little bit. Next slide.

Imagine if we could go from Miami to Tokyo in less than 2 hours. I did that flight a couple of years ago, and I can tell you it took about 17 hours once we left Los Angeles. Of course, it took us a full day to get from Miami over to Los Angeles before we could go there, so imagine what it would be like to be able to get from one place on the Earth to another in such a short amount of time. Imagine what it would do to our national security to be able to put assets where we need them within hours of an emergency situation. Imagine what it would be like for the tourist industry, bed and breakfast, things along those lines.

We can all dream, but if we continue down the path that we're going, we'll never get there. We need to start thinking about what can we do to change things. I'd like to talk a little bit about some things that are not quite as sexy as these things are but to get you thinking about some of the infrastructure things that we need to work on. Next slide, please.

We've had some problems. Traditionally, the space program has been a government-operated endeavor, so we have not taken a business attitude towards this. We have done it because it was a national mandate. We've done it because we are in a contest to get ahead of the Russians. We did it because it was a national security issue. Because of those things, we did not necessarily worry about the most cost effective ways to do things, so we need to take a different approach to be able to do that.

The other thing that we've done is that we have been worried about performance of the vehicle. How do we get those sexy things up there, belching fire and smoke, and get them up into the air? You heard what Stewart said, that I was in flight test for quite a few years, and I really enjoyed jumping into a brand new airplane and flying 800 knots down at 100 feet. That is really exciting. Working on the airplanes, working on the new space vehicles, those kinds of things are really exciting, but if you get the newest Ferrari and take it out on a potholed back road, it is not going to go at the top speed that that Ferrari can run. You need to make sure that you take care of the infrastructure, take care of the roads, take care of the buildings, things along those lines so that you can operate the way that you're supposed to be operating.

In fact, you'll hear probably a little bit more from Carey because Carey does a lot of my cost analyses and projections. We've got things that are telling us that operations and maintenance costs, especially on the reusable side, make up 45 to 60 per cent of the life cycle costs of these vehicles. Yet, we seem to concentrate only on the development side, and then the performance of the vehicle, so again, we need to start thinking about what it is to support the vehicles in spaceports and ranges. Next slide, please.

There are a lot of reasons why we've got problems. Because we've been concentrating on the vehicle, we have spaceports, we have ranges that can only operate for that vehicle. In fact, right now it takes us up to 48 hours to shift from one launch to another launch. We have to reconfigure everything on the range to be able to do it. That's at one single spaceport. If you try to operate between the Kennedy Space Center or out at Vandenberg, you run into different problems. We need to be able to bring this inter-operability if we want to drive the cost down. We need to get rid of, search out all of the hand touch labor, try to get to automated umbilicals, automated fueling systems. In fact, if you come back to this, right now, if we were going to put a payload into the Shuttle in the Vertical Assembly Building, it takes more than a shift, and we've got literally dozens of technicians standing around. We will move the payload a certain number of inches. Then everybody will go around and measure it to make sure that it's going in the right direction. Then we crank it forward another couple of inches and measure everything again.

That much touch labor is going to keep it so that we can't affordably get access to space, so we have to work on the payload infrastructure, the ground infrastructure to be able to drive some of these things down. I'm not going to go through each one of them. You can read. You know, I talked about automated umbilicals. We need to also look at zero- loss systems. Right now we lose an awful lot of our fuels and oxidizers just due to boil-off. We need to work on our cryogenics and all of the technology infrastructure that goes into advanced insulation systems, advanced transportation systems, automated hook-up systems, and things along those lines.

Our disjointed data systems don't talk to each other. You can't go back into history and look at the reusable launch vehicle that we have today (the marvelous machine that it is, the Space Shuttle transportation system) and figure out exactly what are the cost drivers very easily. We need to have data systems that are set up to the point where we can go in and mine that data and then the decision support systems that will allow us to do all of the things that will be able to process the vehicle and then do the logistics on it, getting it ready for flight.

We don't want to be in a position where it's 115 days between landing to launch and part of it's because we have disjointed data systems that can't talk to each other. We need to use industry standards on a lot of things rather than coming up with unique systems that are designed specifically for a particular vehicle. We probably all are aware of the frequency spectrum and bandwidth issue and what that will drive us to. Next slide, please.

What do we need to do? Well, we need to start setting up the spaceports and ranges so that they can attack the architectures no matter what they happen to be. Have a generic architecture, try to drive toward a more airport and aerospace type activity. Make sure that the vehicles can go through the National Aerospace System without causing problems. Make sure that when we bring a vehicle in that there are standard interfaces and that there are standard ways to operate and that we can do all of these different types of missions without having very specific infrastructure for each individual type of system. Next slide.

We want to make sure that we're set up to do the high flight rates. I'm not going to blow smoke and say, like we did several years ago, that we're looking at thousands of launches per year and that we're going to literally have satellites all over the sky. No, but what we need to do is drive the costs down, drive the infrastructure down so that it is affordable to get up to space. You know, right now if you're using the Shuttle, it's about $10,000 pounds to orbit for each pound of payload. If you're using the expendables, we can get down, depending on which expendable you're talking about, to anywhere from 2 to 5,000 pounds per pound to orbit. If we really want to be affordable, cost effective, we need to drive the cost down into the hundreds or tens of dollars per pound to orbit. The only way you can do that is by addressing all of the different parts. We have to look at this as a system, not as a vehicle-centric or payload-centric idea. Next slide.

What we are putting forth is that we will look at this as a macro space transportation system which includes payload, vehicles, spaceport, range, and the inflight mission control system and that we need to make sure that we are appropriately funding each one of the different areas. What we want to do is to get away from the idea that we've got lots and lots of time on the ground for a little bit of flight time and go to a very small amount of ground time and have lots of flight time.

How are we doing this? Well, we've got two national forums, the Advanced Range Technology Working Group and the Advanced Spaceport Technology Working Group. They have come through with draft baseline plans that are in coordination right now with Air Force Space Command. They've gone through the coordination at NASA, and we're bringing it up to NASA headquarters that has a technology road map out to the future of where we need to invest. Next slide, please.

We need to invest in standardized infrastructure. We need to invest in having the advanced technologies infused into the system at the appropriate times. We need to have these types of things where on-demand propellant loading – I skipped over this but we need to get away from the large fixed infrastructure that we currently have, that set of radars that are sitting down range so that we can track everything going up to orbit. We need to get to the point where we've got on-demand telemetry and radar coverage or other sensor coverage. We need to be able to do all of the launch preparations, the ground operation preparations and then have the flexible data management systems.

All of these things are in those road maps that I was talking about, and I encourage you to go take a look at those things. I did bring a couple of copies if people want to look at them or they can go on-line and find those things out. Next slide.

Now, I've been in flight test for a long time. I know what it takes to get new technologies out into the field. People don't believe that they can use them in their own programs because they're too new, they're too controversial. They're untested, so we need to set up a system where we go through and test and prove that these capabilities are mature enough in an operationally representative environment. We need to have ground demonstrations and set up to have integrated ground test capabilities so that we can prove all of those new technologies.

Then we have to have a series of flight demonstrations. The good news is that back in 2000 after the Interagency Working Group presented their report that tasked the Air Force and NASA to get together and to work on the technology road maps, we've been doing that with Air Force Space Command now for several years. It looks like both sides are getting ready to move forward with programs that we're doing in conjunction to start infusing some of the technologies.

Over on our side, we're doing spaceport and range technology. We're trying to set up what we call the FIRST, which is the Future Interagency Range and Spaceport Technology program. It is winding its way through the budget mechanisms up at NASA headquarters. At the same time over in Air Force Space Command, we've got two sister programs, the Operationally Responsive Space Lift Program and the Global Launch and Test Range Program, which look like they're going to be funded for analysis of alternatives in the 2006 time frame, so we're pushing forward with these ideas to be able to get them out there. What we envision is maybe a $25 million investment in the short term, in a couple of years after 2006. Then there will be an acquisition program after that. Right now, we've got preliminary cost effectiveness, return on investment type things that say we'll get about an eight to one payback on dollars invested going into range and spaceport technology infrastructure. Next slide, please.

Solution? I kind of talked about it. We need to transform how we're doing into an airport-like operation, more standardized. Can you imagine what would happen in the airports if you flew in in your airplane and you had to find the right type of fuel connector rather than having a standard connector. Well, in the space business we have to have different connectors for some reason. Everything has to be different. In fact, when we were first putting the International Space Station together our major contractor decided that rather than a 16-byte technology or a 32-byte technology on a lot of the things because the industry was just shifting from 16 to 32, they came up with a totally unique 24-byte technology for all of their systems. We need to get away from that.

The multi-agency cooperative effort, I failed to mention that the FAA, obviously, is a part of our first program. Stewart is helping us with that. Rich VanSuetendael, in the back there, is helping us on it, and we're pushing forward. So we need a multi-agency cooperative effort to pursue this national vision. Next slide.

That's about it. If we ever want to achieve this vision, then we need to make sure that we are paying attention to all aspects of the space transportation system, not just the vehicle, not just the payload, but also those potholed dirt roads that we've got out there today and try to fix the infrastructure that's there so that we can drive the costs down. Thank you very much.

(Applause)

MR. JACKSON: Now Carey McClesky will try to touch on the technology and launch vehicles for the future.

MR. McCLESKY: Thank you, Stewart; thank you, Jim.

Good afternoon. I'd like to talk about flight systems, even though we just heard that a vehicle performance-centric approach is something we need, perhaps to get beyond, but I would like to touch on flight systems, the future, 20 plus years out, what might they look like if they're going to be compatible with commercial growth, what might be some of the characteristics of them. Next slide.

I want to set the stage in a couple of charts up front here on what kind of environment would be compatible with economically viable space transportation, commercial space transportation. Obviously, we've got to be in a different position than we're in now. We need a sustained, growing space transportation demand. We're going to need in-space infrastructure if we're going to go out beyond Earth orbit. We'll need power. We'll need information, communications, so our Earth-orbit infrastructure will begin to grow outbound. The needs for supplying and maintaining those will also grow and that will create growth in space transportation.

In addition to the science and so forth that helps extend the interest in going out into space, I think it may be time where we need to start thinking about what can we build in space and what can we construct in space and think about moving from missions and satellites into space freight and that kind of thing. That will create a great demand for commercial space transportation opportunities as you look out in the future. Also human space access opportunities, and I'm not going to touch on that in great depth. I think that was well covered earlier this morning.

Another aspect is what would be some of the success criteria for future operators and owners of commercially viable space transportation systems. It's already been touched upon, the high flight rate capability will need to be there in order to earn revenue. I think that was mentioned this morning. I also think that as you look out 20, 20 plus years, you're going to need to see some independent operators with independent purchasing power over the manufacturers as it exists in just about every other commercial transportation industry I can think of.

The freight and passenger driven economic demand will also, I think, characterize that, if you think about that kind of environment. Perhaps not in the near term, in the next 10 years, but if you go out 20 plus years, I think these are some of the things that may characterize what kind of flight systems you would need to be compatible with all of these things. Next chart.

Jim mentioned installing payloads. Now this is a horizontal situation, and it looks very much like anything that would be on any pad today for the expendables or so forth. It's a bunny suit environment and lots of folks intricately stitching the payload into the flight system. I think we're going to need a whole different situation if we're going to have the high revenue return rate. Very high flight rates, with a freight type situation with modular payload and payload packaging units much like FedEx and some of the others use standard payload packaging and so forth.

I think that what’s going to be another characteristic is that we may not just be launching a fully functional satellite in the future, but we may be sending up pieces to build really imaginative large-scale infrastructure to do really great things in space and out in the future. Next chart.

This is my final chart for setting the stage on human space flight. I think it's inevitable that humankind is moving out. You can see the growth rate from 1961. I do actually have something in common with Alan

Shepard. If you watched "The Right Stuff," he was there on the launch pad wetting his diapers. Well, I was about 10 months old in 1961, wetting my diapers as well. So in any case, if you look back from that period just a few privileged people were able to go into space. That's still somewhat the same, but you can see during the Shuttle era, say what we will about what was envisioned in terms of flight rates and costs and so forth, I think one of the really major accomplishments is really bringing up the level of human access. I think when all is said and done, that history will acknowledge that benefit, so that will extend out. Next.

Actually, if you look at the current policy, we're going on out to the Moon and so forth. Actually the opportunities on the government side may go down a little bit, but for a group like this – next – I believe is the commercial opportunity to grow here because the opportunities for extending humankind into space may well fall in the commercial realm to fill, much as it has in public air travel. Next chart.

Well, let's get down to some nuts and bolts. This chart here actually is an hour and a half briefing. I won't go through all that, but it shows you the types of concentration of work for a typical space transportation system. This happens to be the Shuttle, which you may say is not necessarily typical. If you look at the types of generic functions, the way we categorize things, even though the percentages may come out a little different, it's quite similar for almost all of the concepts that I've seen here this week.

There's unplanned troubleshooting and repair, particularly for the RLVs, but even in the ELVs we see items arriving that require items to be troubleshot or repaired. Lots of assembly activities and many concepts. I think Elon Musk had a great thought there in keeping the number of stages down and so forth. That helps limit the assembly requirements. Servicing, quite often we're criticized in the Shuttle program for testing and over-testing, but one of the big items, and this creates a huge infrastructure, is the systems servicing, particularly the fluid systems servicing. For example, the number of interfaces between the flight system and the ground and the Orbiter processing facility is 402, almost the majority of which are fluid interfaces. That's a lot of things to hook up, a lot of things to operate, a tremendous ground support equipment infrastructure all its own. There are some other functions here, but I think these four here are the major ones that need to be addressed in any future flight system that will be compatible with our vision out there in 20 years and compatible with the type of airport-like infrastructure that Jim just went through.

We've got to have increased design life in our flight system hardware. That will help cut down the unplanned troubleshooting and repair. There are about 400 items we put on and take off a typical Shuttle vehicle, 100 unplanned, 300 planned, based on limited life items. We have to have simple, robust, highly dependable solutions. One of the reasons we have flight-by-flight certification in this industry is the engineering confidence is not there based on the amount of unplanned flight-by-flight activity that goes on. We've got to get to fewer systems. The way I think we need to do that is get really intelligent about how we put together our subsystems and not overdo it in terms of hardware and separate subsystems to do functions.

If we do that, we can cut down the number of ground interfaces, both in the expendable world and the reusables and so forth. We need no assembly required at the spaceport. Building up an SRB is not simply a matter of stacking the solid segments. Obviously, that is a highly visible assembly activity, but there are a lot of systems, cable tunnels, routing, thermal protection system applications, and so forth. If we can get the systems that arrive to the operator with no assembly required, then we're there.

I think the other thing that we need to look at is a process for obtaining a high degree of engineering competence, whether that be on the one extreme, the FAA certification airworthiness type situation, the other extreme being flight-by-flight certification. Somewhere hopefully more toward a type certificate process. I can't tell you right now what that is, but that's going to be a very important piece to bringing about commercially viable transportation where an operator can depend on the system and not have to do a lot of verification. Next chart.

Now, this is a notional concept, and please don't get hung up on the shape and all that kind of thing. Just take away from this not the whole bird here but just some of the key elements. This is a notional concept that came from one of our folks in the office. I've called it R4. Russ Rhodes in our office came up with this, so I called this Russ' Really Responsive Rocketship, but anyway a couple of the key elements here. You've got a single fully reusable core element.

He did have a crew escape there. I kind of chastised him for having too many engines; we've learned a few things over the years, and we probably wouldn't want so many engines. Parallel tank arrangement, now this is kind of key in terms of operability. You get elevated locks, tanks and things like that, and you get into some added sub-systems both on the ground and the flight. If you can bring them all down to the ground, they're easier to load, easier to condition. Have pumps pulled away from what are now engines and pull them up toward the tank, and you can thermally condition and load much faster than we do today. It takes hours and hours to load and thermally condition large-scale engine systems.

These would be more like back in the V-2 days, and we saw the V-2 concept. The turbo pump is separate from the engine. I don't want to go into all the details here, but there are a lot of different advantages to doing that. Eliminating closed compartments, if we can find methods of doing that, this concept may not actually show all that, but the idea is to come up with innovative concepts, arrangements, that reduce the amount of subsystems and hardware and, therefore, interfaces to the ground and infrastructure and so forth. Next chart.

We're actually pursuing this in a slightly more formal sense now. We've had a design for operations contract that has just wound up, and this is from a draft report. Some of the key features we just talked about are incorporated in this, and we're using Dr. John Olds from Georgia Tech. He has a small business also, SEI. We have him running the codes for us and so forth. We've had some limited success with that. What we're finding, though, is that a lot of the codes that are used out there have false assumptions on the weight, so if you use some of the ideas we're talking about we're going to have to go back and reiterate the subsystems a little bit. Next.

These are things to explore. I think one of the main things we learned out of the whole exercise is that perhaps we ought to rethink about starting from drawing the cartoon like we did here and then trying to figure out what the operability is. We really need to understand, technical discipline by technical discipline, what the system's needs are in terms of power, mechanical and electrical, data, communications, propulsion and propellant servicing, thermal management. All those things need to be looked at independently. Look at how they could be done smarter than our traditional off the shelf designs, and really design the next operable vehicle generation from the inside out. Then discover what geometries are compatible with those kinds of streamlined lower weight systems. Next chart.

I think the outlook is we've had one attempt now at reusable orbital flight elements; that is the Shuttle Orbiter. The techniques and expertise are available, although get them quick. If the current policies retire some of these systems and that expertise, their knowledge is lost if we don't -- and I'd like to echo what Dr. Koller says, the knowledge capture is very key in passing it on down. Those are now available, I think, for designing operationally effective space systems. Next chart.

Of course, Jim mentioned the whole spaceport and range technology initiative, and what do advanced spaceport systems look like that could support the kind of high commercial operations tempo being envisioned. Next chart.

I think that affordable, responsive, and safe access to space is on the horizon. I tend to think that in the out years you don't have to just pick two if we work on elegant solutions. I think some of the ones we've seen this morning actually simultaneously hit all three, but it takes a lot of work. You've got to go through 99 solutions to get to the one that's really elegant, but I think out in the future we will find that. I think that is on the horizon. Next chart.

There are tremendous commercial space transportation opportunities here if we latch onto them. In conclusion, the best is yet to come.

(Applause)

MR. JACKSON: Well, now that we have talked about the infrastructure in the next 20 years and the technology that will have the possibility of using the infrastructure, I guess I want to ask the question, why, or what's in it for me. Well, Tim Huddleston will address that in the sense of entrepreneurship. Thank you.

MR. HUDDLESTON: Thank you, Stu. I just said to him, “you hope I will.” This is a pleasure for me to do this. This is something, obviously, I'm very passionate about. Carey, in your remarks when you mentioned the incident with Alan Shepard having to relieve himself in his suit, you said, you know, you were wetting your diapers at the same time. It made me think. There are probably three times in your life that you're going to do that: when you're a child or if you become an astronaut and you have to wear the Depends®[1] and you may wet your diapers then or if you ride in a taxi in Washington, D.C. I can assure you, you will probably wet your diapers then.

(Laughter)

This is, indeed, an honor for me to talk to you about something I'm very passionate about. Let me tell you first about the organization that I represent, the Aerospace States Association. I'm its Executive Director, and the Aerospace States Association is an organization that represents about 40 states currently. We represent the governor and/or the lieutenant governor's office, basically the executive branch level of state government, and we're interested in all things aviation and all things space. Aerospace to us means all things aviation, all things space. Now, my passion, having a degree in astronautics, is the space side of things, but there's an interesting thing that we see as we work policy. That's

[1] Depends is a registered trademark of Kimberly-Clark Worldwide, Inc. or its affiliates.

what our real focus is, to work the policies that are essential to advance air transportation and space transportation in this country, to make sure that this nation fully realizes any and all opportunities that can be afforded by an advanced aviation system and an advanced space transportation system, and that's key here.

It's exciting to me to have that opportunity to work in a role where we can be on the cutting edge of formulating policies that can do that. I just finished up my tenure as the chair of the National Coalition of Spaceport States. Andrea Seastrand, by the way, has just been elected the new chair, and what a dynamic person she is. Then they chose to elect me as the secretary, so I went from being chair to the secretary. I looked at them, and I said, "You all really want a boy from Alabama to be taking you all's notes?" but they seem to want us to do that.

I'm really excited because that group is looking at infrastructure issues. That group, enjoined with what became the first program to really start looking at the future of infrastructure and how it will play a key role in not only servicing the systems that are being developed but in a co-relationship of really developing the concept for a total space transportation system, one that can service every element of this country. We're talking about a capability that's not limited to being launched from a range. A range is a very important thing. You understand that if you're going to test a new concept, a new system, you want to be in the most safe and reliable environment.

If you go play golf with me, you won't need to be on a golf range because it's pretty dangerous. You want to be using ranges in cases where it is important to understand the capabilities of your systems and how they will respond and perfect them, test and evaluation. Once you get to the point where you have a reliable system, you want it to be able to operate in the most free and unrestricted environment possible. I can tell you the first program, ASTWG and ARTWG, the two working groups that have helped form this road map that now has become the first program, has been very proactive in looking at how do we really get to the point where we're, as Jim Heald said, operating in a more aircraft-like scenario. Now I don't mean lost baggage, but I mean in the capability of literally flight on demand.

Lowering that ground problem that Jim showed, that pyramid that shows you spend all your time on the ground, and you really ought to be spending it in flight. In the airline industry that's called deadhead operations. A deadhead flight is the worst thing you can do. It means you're flying an empty plane. If the plane is sitting on the ground, it isn't generating any revenue, but this is the point. We've never really had to approach this concept in space.

What Stu asked me to do is to come up here and to try in some fashion to give you a view of what maybe the states and maybe a lot of individuals who are trying to be visionary are really trying to think of, how the future can look, and what results we're trying to achieve. Now, here's what you need to understand, and I know I'm preaching to the choir. I've got to say this right now, there's an AST individual who's not in the room right now, but she has said something that's so significant on several occasions. I'm talking about Paula Trimble, and she's not in here; oh, there she is, sorry, Paula. She says something in just about every venue that I have an opportunity to be in and it's this: "You know, we are so good" – I'm paraphrasing but, "We are so good at preaching to the choir, but we need to get out there and work with the congregation." You know, that's true. We're here today, and I'm going to say some things that you already know, but we need to be saying these things to the people, to the public.

Now, I will tell you in a minute how ASA is going to try to do that and where you can help us do that, but just to ground you in where we're thinking. so we're all on the same sheet of music: What we're thinking here is that we have a process, a way we approach the access to space that was handed down to us really from a great national goal. John F. Kennedy challenged this nation to put a person on the Moon, to put a man on the Moon and return him safely to the Earth. That was the challenge. That was an incredible goal. We undertook that goal almost in a carte blanche approach with some initial reluctance but ultimately with total buy-in. Congress supported that effort.

The problem is that we didn't really understand what the vision was at that time. What were we trying to accomplish? Where were we trying to go? A goal is something that has significance and can be measured and has an ending point. Now, the President of the United States has, in my opinion, wisely thrown a challenge to us of another national goal and that is to return to the Moon and go to Mars. Now, that is a challenge in the exploration arena, the exploration of space. What we have to do, as leaders in the space community, is to make an assessment of whether we can support that kind of goal, and to challenge the American people to understand what the vision is, the total over-arching vision for space and I mean from all sectors; military, civil, in this case exploration, which is what the President has challenged us on, and commercial, space commerce.

What are we trying to accomplish here? Well, in my opinion, it is about what this country is about. It is about what I like to call the American experience, and that is to find opportunity, to find challenge, to realize great economic gain for the country, to reach into our inner souls and do the things that some people say can't be done but to do them because that's what we're about.

Now, there are a group of entrepreneurs in this country and, in fact, several represented in this room, that I think exemplify the American experience like no one else can do. They are saying they're going to build vehicles to go into space to open up the economic opportunities to access space. Some are going to approach that in aircraft-type designs and operations. Some are using totally reusable vertical concepts and some totally reusable horizontal concepts and then, of course, the myriad in between there, the hybrids. I will tell you, there are people that they run into on a daily basis that kind of giggle when they say what they're going to do. Later, they probably behind their back say they're crazy, say, "This doesn't make sense," or "These people are nuts."

Well, do you know what, they probably are nuts. I say that because when you look at the greatest inventions in this country, in this world, the greatest opportunities, they were all done by the people that were nuts. The guy that invented the telephone was a nut, okay? The guy who invented the light bulb – I mean, taking a piece of bamboo and trying to put electricity through it, that guy was a nut. You get my point, people laughed at these people and made fun of them. What were they trying to do? They were trying to do something that somebody said could not be done. The entrepreneurial experience in this country is those people who want to find a better way, want to find a more dynamic way, a more challenging way, a way that yields great results. Now, let me tell you, the warning I've got to give you is we assume some times that entrepreneurs are strictly business people. There are plenty of business people out there who are not entrepreneurs, but there are also plenty of entrepreneurs that are not necessarily business people, and that's important to understand.

You can find entrepreneurs not necessarily only in the commercial world but in the military. I'll tell you there are some Air Force personnel that I have spoken to in the last 3 years of working on ASTWG and ARTWG, working through the coalition, that I think are some of the most innovative, thinking out-of-the-box kind of people. What we've got to do is shed a little light on that thinking. Then, there are those in NASA, and I'll tell you NASA is populated with some of the most intelligent people, most creative folks, most dynamic folks. Carey McClesky energizes me every time I talk to him. He has a lot of great ideas, but you know the problem is we live in a bureaucracy. We live in the most unusual form of government. Winston Churchill was so correct when he said, "Democracy is the worst form of government, excepting all other forms of government." The point is that we do have challenges; when government tends to grow a little bit too big, you get meddling.

I think one of the most dynamic people within the federal government is Patti Grace Smith, besides the fact that she's from Alabama originally. She is one of those innovators, one of those entrepreneurs within government, but she has to deal on a daily basis with that big dragon out there called bureaucracy. I know because I try to help her slay that dragon sometimes, and it is tough.

The problem is we've lost sight of the fact that this country is built on that entrepreneurial spirit of creativity, of challenge, of looking for opportunity. We've lost sight of the fact that the American people want us to invest in something that's going to put something back in their pocket and food on their table and take care of their children.

We've lost that when we talk about space. Because we, unfortunately, in successfully responding to that wonderful challenge, that wonderful goal that John F. Kennedy gave this country, we failed to learn and understand what the vision is and the direction we had to go in order to realize that vision. When we succeeded and we put Neil Armstrong and Buzz Aldrin on the Moon, and we brought them back, the goal was successful, and it was completed. Now, does that mean you stand down the program? No, it means you understand where you go from there.

We didn't do that so what we have done is, in effect, has been reliving that goal for the last 30 years, continuously doing the same thing. We can't let that happen this time with this new challenge from the President. What the President has said is, "Okay, I'm going to respond to those who have asked for us to do something exciting and innovative with the American space program." When I say American Space Program, I'm referring to the exploration of space because we want to all talk about the American space adventure which is all the programs; the military programs, the DARPAs, the entrepreneurs. We want to talk about all of that together and how that will ultimately equal putting bread on the table of American people.

Well, when you look at the Lewis and Clark expedition, that's what the Lewis and Clark expedition was about. How do we open up this country for commerce? When you look all the way back, some of you have unfortunately heard me use this thing until it's probably just absolutely tiresome to hear, but when you look back at the Columbus expedition, to Christopher Columbus, it was about excitement, exploration. Of course, he wanted a personal gain out of that as well. When he presented that to the king and queen, they said, "No, sorry, can't do it." In fact, he started out in his native country of Italy, and they said, "No, we're not going to do that."

Then he went to Spain, to Ferdinand and Isabella, and he said to them, "I want to go and explore." They said, "Not with our money." Later he came back, and he said, "I can find a shorter route to the spice trade. I can find a way that you can corner the industry, the market." Spices at that time were far greater, far more valuable than perhaps even gold. They liked that, they liked that idea, so they funded his mission. Now, he didn't necessarily find that shorter route to the spice trades, but what he did was open up economic opportunity for Spain unparalleled ever in history to that point. Folks, that's what I'm saying we have to do. We have to take the challenge the President has given us. We have to take the things that – the programs we're working on, the Jeff Greasons and the George Frenches of the world that are out there trying to open up new opportunities with new vehicles. Tourism, adventure travel. Like I say, going back to what I said earlier, if you really want adventure travel, just ride around in Washington, D.C. in a taxi. That's far more scary than climbing Mt. Everest.

If we're going to do these things, we have to do these things in concert with the greater – we have to think about things like the FedEx model. I mean, here's another crazy guy who came up with this idea that he could ship these packages around the world in 24 hours. Do you know what he has done? He has enabled thousands of businesses that exist solely because FedEx exists. If FedEx goes out of business, if all the carriers go out, those companies go out of business. Whole new opportunities, whole economic direction.

Ladies and gentlemen, in conclusion I want to say that, as a community of space leaders, we have to assemble a message that speaks to the greater vision, that entrepreneurial spirit in this country of how we challenge those entrepreneurs to succeed; how we challenge the investment community to invest in that; how we create that aircraft-like operation; how do we fly on demand; how do we create robust, reliable, safe, economic space transportation. We have to work those issues. How do we make sure that the New Mexicos and the Oklahomas and all the states have the infrastructure for supporting this kind of thing? We can start by working with AST, who is very much excited and eager, in trying to do those things. Then we can do as Paula has said, and go out and stop speaking to the choir. Let's start talking to the masses, and let's make things happen.

The Aerospace States Association is committed to do that. We need your help. We're going to start touring the country. In fact, as some of you know, we're releasing a national vision that actually talks about what I just said very shortly. We're going go out there, and we're going to sell that. We need your help, and we, all together, will do this. Thank you so much. Let's make it happen.

(Applause)

MR. JACKSON: Okay, our next speaker will be Dr. Edward Hudgins. He's going to be talking about future space policy. I know some people look at that and say oh, oh, we're going to get over-burdened with more regulations, but that's not the point. Always remember there once was a dirt road, and that dirt road has a traffic light, so that you could have commerce to pass through. If the traffic light wasn't there, there would be a lot of accidents. So here's Dr. Edward Hudgins.

DR. HUDGINS: Thanks a lot. I appreciate the opportunity to speak to you today. I'll be departing a little bit from my prepared text, so I hope you'll pardon me for that. I want to begin by taking a look into the past, the present, and the future. Now three decades ago, a dozen men walked and worked on the Moon. By the way, in 1969, I was a high school intern at Goddard Space Flight Center and got to watch that first Moon landing close up. It was absolutely thrilling and kept my interest up in space and technology ever since then. By the way, the philosopher Ayn Rand wrote at the time of Apollo 11 that it was like a dramatist's emphasis on the dimensions of reason's power. That is, this was an incredible example of exactly what human beings can do if we try.

It was a wonderful time for any of you who were alive back then. But of course at that time, there was reason to believe that the vision from the movie "2001: A Space Odyssey," would be in our future. That is a vision of regularly scheduled commercial flights to orbiting space stations with private Hilton Hotels, and shuttles going back and forth between thriving lunar colonies. Well, the year 2001 has come and gone, and only about 500 to 600 people have actually traveled in space. A government-owned and operated space station is a downsized version of its original design. It's about 10 times over budget. It's about a decade or two behind schedule, and it might be finally constructed if the accident-prone government Shuttle finally flies again.

Okay, now let's take a look at three decades into the future. Three decades in the future perhaps, what we'll see is thousands of Americans each year repeating Alan Shepard's 15-minute suborbital flight, hopefully without the diapers, at cutting edge amusement parks. They'll feel that acceleration, the roar of the rockets, and see an incredible view, but such trips will actually be at the low end of an industry that makes money carrying hundreds of higher-paying citizen-explorers to private space stations pioneered by that great entrepreneur, Robert Bigelow and Bigelow Aerospace. Those stations will offer more than just a week of floating, playing micro-gravity games, and discovering some incredible possibilities with one's significant other in one's private sleeping chambers.

The stations, telescopes, and conduct-your-own-experiment labs will outshine all museums on Earth in their intellectual illumination. Those stations will probably be popular places for spiritual renewal. Of course, the best science students of the best universities could actually spend a semester in orbit. At that time, perhaps the space energy industry will have begun, at first to provide infrastructure for an increasing number of on-orbit activities and stations and projects but perhaps will now be providing energy for the planet Earth.

At that time, perhaps we'll have a Earth/Moon cycler project that promises even more on-orbit traffic because this craft, of course, will be swinging back and forth, past the Moon, back to the Earth in an endless dance with these two worlds. What we'll see, perhaps, is expanding visits to the Moon. Perhaps we'll see that first lunar base, which I hope will be built by a private company that will still be enjoying a 25-year tax exemption for all of its revenues as payment for building the station without government funds. Perhaps we'll see a base like that expanding, and seeing more settlements on the Moon.

Could this be in our future? I'm going to touch on several of the conditions that I believe are prerequisites for that and then talk a little bit about the government's policy today. Now, we must first acknowledge that only private entrepreneurs can bring down costs and make accessible to all, that is commercialize, goods and services, be they automobiles, airline trips, personal computers, the Internet, cell phones, or space travel. Thus, we must ask what conditions are necessary for such entrepreneurs to flourish, and what, if any, role should the government play in facilitating this process.

Now the essential element for any free market system is private property rights. When we speak of property rights, we mean three things. First, we mean that individuals have the liberty to acquire material and non-material goods and services through voluntary exchanges with others. Second, very important, we mean that individuals are free to use those goods as they see fit without getting the permission of others, including the government, as long as they do not materially damage the property of others. Third, we mean that individuals have the liberty to dispose of property in exchanges with others based on the mutual consent of buyer and seller. The free market is simply the activities that occur as individuals acquire, use, and dispose of property.

Contracts, for example, are agreements concerning the use and exchange of property. Prices are the terms of exchange. Now, one might think of private property in a sense as a private form of regulation, of regulating the use of resources and so forth. The role of government in a society based in individual liberty and property rights is not to limit the liberty of owners, not to regulate the use of property in light of the prejudices of the government officials. It is to protect those liberties and that property. What kind of regime, then, would be necessary if the free market principles that have made America the most prosperous country on Earth are to make space and other worlds, perhaps, prosperous commercial realms as well?

Well, first, a discussion of space enterprise, I think, has to start with the Outer Space Treaty of 1967. This treaty, which was signed by the major space powers, was drawn up before private groups or private entrepreneurs were pictured as actors. Everyone assumed there would be governments out there that are conducting activities. Thus, for example, the treaty made governments liable for the damage done by rockets launched from their territory.

The treaty also states that, and this is a quote here, "Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty by means of use or occupation or any other means." Now, this definition, however, doesn't mention private parties. And further, the treaty does allow for parties to be free to operate in space without the interference of other parties. This principle, I think, potentially allows for sort of a quasi-property rights regime or at least the beginning of such a regime to emerge in space.

Now, I want to turn to a couple of specific space-related activities and see how these principles would be applied. First of all, of course, a major concern about launches from Earth, either suborbital or orbital, is the potential damage to third parties. I mean, that's what the Space Office, Office of Promotion of Space actually does; It worries about these things. Now, I note that passengers on private rockets would frankly, best have their safety guaranteed by a private insurance company. I don't believe that it is the purpose of government to protect the safety of citizens who want to engage in risky behavior. After all, Americans drive cars, bungee jump, sky dive, and do all sorts of risky things. Those kinds of risks, I think, individuals should be taking upon themselves.

It's the third parties that have to be insured and have their safety insured. I don't think we necessarily need government to do this. I think that aside from contract enforcement, the government might not have to be involved. It might be done by private insurance companies. For example, in the City of Paris, at least in the past, the fire codes were not set by the government.

They were set by insurance companies who, after all, had a very strong incentive to make sure that the structures they were insuring did not burn down, right? I think that this is an interesting model. I mean, after all, remember in this country private airlines and other activities are insured privately.

I think that this is a potential way of dealing with risk that would not necessarily require the government. Now, companies – at this point, of course, the industry is very nascent, so I think that there's going to be a transition period, but I think that that's a way to kind of think about the future, 20 or 30 years in the future.

I want to say a few things quickly about slots on orbit. Again, the International Telecommunications Union Regime, which is endorsed by most governments, actually bars private property rights for orbital slots. Of course, what has happened there and what has emerged is a kind of quasi property rights regime where, in fact, parties can obtain a slot in orbit if they basically declare their interest in doing so, ensure that they are not going to interfere with other parties, and register with the ITU. What has emerged is a system where countries, especially less-developed countries, will claim a right and then basically trade those slots, so you kind of have an emerging property rights regime in space for orbital slots.

Now, I think in the future the ITU is going to probably have to be amended to really nail down slots in space as property rights and especially as we get increased space activities, more private space stations up there, hopefully, a whole energy-based space economy and so forth. Now, I want to say one word real quickly about what we're hopefully not going to do, and that is that we're not going to go down the path of the UN's Moon Treaty which was agreed on in

1979. Fortunately the United States did not sign that agreement. It's very similar to the Law of the Sea Treaty. It's a socialist document that declares space resources as the "common heritage of mankind". It bars private property rights explicitly, and it speaks of the equitable sharing of benefits.

That's basically socialism, and I maintain that it's good that the United States has not signed it. We're probably not going to sign it. If we ever do in the future, we might as well forget about becoming a space-faring civilization because socialism isn't going to work in orbit any more than it worked in the Soviet Union or anywhere else.

Now, I'm departing a little bit from my text here to kind of wrap up. I want to talk a little bit about the situation today. The new Bush space agenda is kind of a mixed bag. It's very good that the President is saying that NASA should return to science and exploration. That was the reason why NASA was established. However, given the budget problems with the space station and the Shuttle, I think there's little hope that NASA in the future, in its current situation will ever be able to put up a Moon base or get us to Mars. I think what the Administration needs to do as it's reconsidering the mission of NASA, is to really develop a fuller strategy of privatization and commercialization. What does that entail? Well, a couple of things.

First of all, define NASA's mission very narrowly as science and exploration. Second, turning to the International Space Station, I would get rid of the station as soon as possible and not wait until the end of this decade. The station and the Shuttle each year consume about $7 billion and give us very, very little real science. One of the things you might do with the station is just turn it over to the mostly private Russian rocket company, Energia, and to the private western investors who were in the process of privatizing and commercializing the Mir space station before it was brought down for political reasons.

Now, that might be difficult because we do have international partners after all. One other possibility would be to set up the space station kind of the way we set up airports in this country. Airports in this country are government owned; however, most of the activities in the airport are privately provided, right, you know, the flights to and from the airports, the food services, the cleaning services, those kinds of things.

I think some kind of a Port Authority arrangement like the Port Authority of New York which is New York and New Jersey, something like that might be an interesting transition to a privatized space station. Some other things to do: privatize the Shuttle immediately. Give it away to the United Space Alliance, USA, which is the consortium that actually services the Shuttle. If they want to fly it and if NASA wants to be a customer on it, fine. Contract out for services. In other words, go to a regime where NASA buys services instead of hardware. In the 1920's and `30's, the Post Office, rather than purchasing airplanes and hiring pilots, simply contracted out for mail services to private plane owners like Charles Lindbergh, who was one of those people. That's a very good model we have. There's a great chapter in my book about how that happens, so buy the book.

Shut down or privatize or turn over to other parts of the government anything in NASA that has nothing to do directly with science or exploration or maybe certain cutting edge technologies that I think NASA may have to look into. For example, the Mission to Planet Earth has no business being in NASA. It's something that the Interior Department or EPA or maybe NOAA should do but certainly not NASA, and those other government agencies should purchase data, not hardware and satellites, to help foster a private space industry.

Use prizes. That was something else that was done in the 1920's and `30's by the government. When they wanted something, they would say we will pay X amount for a certain fuselage instead of buying hardware directly. Create a zero-G, zero-tax enterprise zone in orbit for businesses. And my favorite, have a tax holiday, a 25-year tax holiday on delivery for a Moon base. In other words, can you imagine Microsoft or some company like that basically saying, "We get 25 years tax free on all our revenues if, in fact, we build a Moon base." Think of all the economic activity that would be generated from building that Moon base. The government probably wouldn't lose revenue, they'd probably gain revenue from such an operation.

There are a lot of interesting ways that we can go about doing policy. Now, I want to say one final thing, given the nature of the audience here. I think we should reconsider completely our regulatory regime as we're looking at these new missions for NASA. I think that the Associate Administrator for Commercial Space Transportation might provide a very useful service by exploring ways to allow, for example, private insurance to take over the insurance of third parties' safety. Now, of course, because launches are still relatively infrequent, insurance companies might not have a good way of determining how frequently accidents might occur, how to prevent them, and what sort of rates to charge. Further, I realize that it's not often that a government agency is actually asked to figure out ways to work themselves out of a job, right?

But in a dynamic and growing market, the workers in such agencies likely would find more jobs and more opportunities in the private sector.

My model is this, at the Kennedy Space Center, there perhaps are three or four Shuttle flights a year at best and a few flights of expendable launch vehicles. I would like to see the Kennedy Space Center privatized and look more like the nearby Orlando International Airport. I think a growth agenda is what we should be looking for. It is only the private sector that does that, so let's hope that the vision of America as a space-faring civilization, a vision that has been blurred in recent decades, will emerge as government opens space to the private sector and thus, I think in the long term to all humanity. Thank you.

(Applause)

MR. JACKSON: Okay, our last speaker to come up will bring everything up forward and try to give us a perspective from the public end. Joan?

MS. HORVATH: All right, well, thank you very much. It's always scary to be the last speaker because you know how men like to talk. All right, so why are you here? Anybody – why are you here? You're here because you believe in something, right? A lot of you are taking personal risk, a lot of you are taking economic risk. You're here because you believe in something, and what I'm going to tell you about is that's not good enough. It's not good enough if you sit there and say, "I believe," because you have to go out there and tell people what you believe in and why it's important, and that's what we're going to talk about. Go ahead.

All right, what has to happen in the next 20 years, or none of this is going to work, is that space and space exploration has to involve a much wider swath, more types of paying customers, we just heard about that and space has to become mass market. Why can I say that, what's my credentials here? Go ahead.

As background: The aerospace industry is tiny. We're a very insular industry. I was at NASA for 16 years, at JPL, and it's very easy to look inward and say, "Oh, well, you know, the whole world consists of these handful of flying corporations," but if you put together Boeing's market capitalization, plus Lockheed Martin, plus Orbital, it's significantly less than Time Warner. It's a tiny fraction of Pfizer, and I'll let you amuse yourselves figuring out what the biggest product is there, and look at Microsoft. This industry as a whole, the mainstream launch industry, is a blip. Go ahead.

All right, so how do we change that? We have never, as an industry, been in a mode where we go out and talk to the general public. As an industry, it doesn't happen. Commercial enterprises need visibility in the private market to survive, and it's hardest at the early stages. I work with a lot of small companies, tiny companies trying to get going. One of the things that I did, I was at JPL for 16 years, and I started out as an engineer, and I migrated into our commercialization office. I put together JPL's short-lived program that worked with the entertainment industry. How many of you own a JPL Mattel Mars Rover? Does anybody own one of those? Okay, a few people do. That was my program.

That was wildly successful. There were quarter-mile long lines to buy those at one point. Actually, I got the first one by arm wrestling a Hell's Angel which is a story I can tell you some other time. Except when he found out who I was, he gave it to me because he thought – he said, "Man, that is like cool that you came up with this, that is like cool, man." We need more Hell's Angels on our side.

So I put that program together, and I'll talk about it for a minute and then migrate out to circumstances that are very telling. But anyway, I'm trying to go out and get these folks sponsorship. So I say, all right, you know, here's this wonderful company, Company X, Company Y, Company Z. They're doing this great stuff. They have this great technology. I know a lot of venture capitalists from my work at JPL, and they say, "Oh, you know, space, doesn't NASA do that? You know, it's a government thing. Why are you talking to me at Silicon Valley about this?" Or you go to an entertainment company, and they say, "Oh, I can have images. Those pictures may be great, but I can do them a lot cheaper by just doing them with computer graphics. Why should I actually bother because it will be all jittery? The quality won't be good, so why would I want pictures from a real space vehicle? That's no good."

"Who are you?" I get that a lot, and "It will cost how much?" because it costs too much to go to space. Go ahead.

Let me tell you about two experiments. Vision is good, but you have to do experiments. Most of us are scientists or engineers in this room, a few lawyers. You've got to do experiments, so I did an experiment. From 1995 to 1999, I ran a program which I developed at JPL in partnership with toy companies. That's the most famous product there, the Mattel Rover on a little base there, a lot of licensees. That was the biggest tech transfer program in NASA by a lot of measures for quite a while. Generated a royalty stream. We were putting it back into education. TV shows developed partnerships with us. One afternoon after an interview with myself and the producer of "Babylon 5" appeared in the Washington Post, I got a call from NASA headquarters saying, "Who authorized this program, this is terrible. This is awful. It trivializes the space program. Education is about posters to schools," and they turned the program off.

And so I left. I was joined by the producer of "Babylon 5" and my company Takeoff Technologies. That was in 1999, and we tried to pull out this idea. Our idea is that you have people out in the field, you have scientists doing interesting things. You have people developing vehicles, all kinds of vehicles, not just space. You have entertainment companies who make stuff up, you know, which is interesting but it's not as interesting as the real stuff. How many of you have snuck – you don't have to admit it because there's all kinds of government people here – how many of you have snuck into a room just to be in a room with flight hardware that was going somewhere? I don't work there any more, so I can confess, okay?

How many of you have snuck a friend into a bunny suit just so you could be in a room with something going somewhere? Why is that so cool? It's so cool because it's real. People want to touch something real. People wanted those Mars Rovers because they knew they were accurate, and they were real. I just got tons of e-mails and tons of letters about how excited people were to hold in their hands something that worked the same way.

We think there's a high leverage overlap there. The tourist folks are a link between vehicle providers, entertainment companies, sponsors, all that sort of stuff. Traditional NASA-style outreach links up field scientists, schools and universities. We think we can kind of go in the middle. Go ahead.

So I said, all right, that first experiment was so much fun and had such a good ending I'm going to do another one. And I did, through a whole bunch of incredibly convoluted routes. I was born in New York City. I went to school at MIT and then moved to Los Angeles, so it's entirely obvious that I would start a company in Frederick, Oklahoma, population 4600. Frederick, Oklahoma – and I have some Oklahoma folks here today – Frederick, Oklahoma, is a little entrepreneurial company masquerading as a city. What they did is they came to me and said, "Look, we want to come up with some interesting things to do to bring our kids to a different level, to excite our kids about science, to tie them into industry and to do some stuff," so we came up with this idea, which I give them fully half the credit for.

What we said is, "All right, let's figure out a way to take student experiments to environments that they normally can't get to, not just flight experiments but also to the deep ocean, and let's figure out a way to develop these early stage vehicles." As I told one of my clients that's developing vehicles, "Kids are cuter than you are." He sulked for a week. That's okay.

The way Global Space League works from the vehicle developer side is they come to us and say, "Look, we need to do this test." I've been working with a lighter-than-air company that is developing some interesting things, and they say, "Well, you know, we'd like to get this capability, we'd like to try this. We don't have any money." We introduce them to some sponsors who want to see these global space leap payloads go. We give them some introductions to local folks because a lot of them aren't used to selling themselves. We aggregate experiments from around the country. Our schools subscribe to Global Space League. Then they compete for slots to go on these flights. We have made a point of not being tied to any one company. Various companies have tried to have their own sponsorship programs. They have tried to have their own education programs, but if you're tied to one company, maybe you'll fly once or twice a year. Our goal is to have two or three events a month, and we've done that a bunch of ways. Go ahead.

The way it works for students, I sort of alluded to that, schools subscribe, the State of Oklahoma was nice enough to cover 50 schools to get us started. We've had some sponsorship in California and in Alabama of all places. We have a school in Alabama, and we're gradually getting the word out. Schools subscribe and so far every school has been sponsored. The schools don't have to pay anything to ship an experiment along. We do events. We've done some pretty big events mostly in Frederick, but we're starting to spread around with partners, such as museums, and we're doing buddy schools.

A school in an environment that another school would think is exotic goes out and does an experiment for them. You say, "What does this all have to do with us?" Go ahead. Well, what we've been doing is finding ways to get little tiny amounts of money to people very early. We have an experiment that we've been doing that's very popular. Now that the FAA out in Oklahoma City has figured out what we're doing and that we're not terrorists, it's worked much better. We have kids make paper airplanes, and we take them up on lighter-than-air vehicles to 100,000 feet, and we let them go. Every kid has a serial number, and the planes have a sticker on them that says, "I'm a space plane. If you've found me, go onto this website and type it in." So you can have contests for kids to see how far this goes.

It's very easy. It's very low stress for our lighter-than-air entrepreneurs. Planes go 90 miles, and the kids get lots of bragging rights and all this kind of stuff. We did a Shuttle *Columbia* memorial that way, and you can see one of our kids in there, a Frederick Bomber's outfit there. This particularly appeals to girls and particularly appeals to girls at the critical period when girls tend to turn away from science, which is one of my passions. Girls turn away from science at about age 12 or 13, and for some reason, just anecdotally, girls really, really like this program. Go ahead.

We have been very fortunate to have a partner in Santa Clara University in Silicon Valley. What they've been doing is providing us with lots of very cheap vehicles to do some of our early things. They have some remote control planes, a little blimp, a submersible, and we're going to use the submersible in a little bit. Go ahead.

My idea up here and the reason I'm speaking here is that what we have to do is you can have all these grand plans, you can have 20-year plans, and you have to have 20-year plans, but you have to have a means of doing baby steps. And so what we've set up here is we said, "What we're going to do is to find ways of funding people to give them grants." The way our 501(c)(3) is set up, we can give very small development grants. so we give little development grants to folks who will somehow or other incorporate our kids' payloads.

We give small development grants to universities to build hardware which perhaps a small company couldn't afford to build. We've worked with a couple of universities that have very, very sophisticated electronics programs. They just need a tiny bit of cash to actually make whatever it is. Then this entrepreneur gets something that would have cost them hundreds of thousands of dollars. It doesn't cost them anything, and they also take along a bunch of paper airplanes. So far, paper airplanes have been our signature thing. I keep trying to have more serious science, but everybody likes the paper airplanes, so we haven't gotten away from it.

We have an interesting board. I'm Executive Director. Jeff

Patterson, who is on the ground in Frederick, is terrifying at getting volunteers. Our other board member is Donna Shirley, who some of you may remember as the Director of the Mars Program at JPL. She retired from that, and she's currently director of a new science fiction museum in Seattle, which is going to open up in the summer. They're an obvious partner for us in a lot of this. Then we have some other folks that make sure that I don't get in too much trouble, tough job though that is. Go ahead.

We've done very well with this. At the small level, we have a lot of enthusiasm from sort of traditional rural sponsors. This is done best in rural districts. I won't read those. You're supposed to be impressed at the sheer length of the list. Go ahead.

What should you do? Well, the first thing you should do is figure out ways to take baby steps. If you're one of the folks here from a big organization, partner with a little one. Partner internationally. If you are enthused, and if you sit here and really believe, leave your PowerPoint at home. I'm speaking to you in your native tongue. I figured I couldn't give a talk to this audience without PowerPoint. Leave the PowerPoint at home if you can.

Speak English to reporters and if you are doing anything the least bit interesting that involves a vehicle going out to sea, going out any place interesting, drop us a line, and tell us if you can take anything along. If we can, really, really quickly, I have a video that's a minute and a half. It will just barely fit, I think. This is the view from a robot vehicle taking off from Frederick, Oklahoma, carrying – this one wasn't carrying paper airplanes. This is what it looks like if you're on a lighter-than-air vehicle that weighs 4 pounds.

One of the things we do is have kid reporters on the scene talk through these things. There's no sound on this one just because this happens to be a version. Here, you're climbing out over Oklahoma. This is near Tipton for anybody who is from Oklahoma and Lake Frederick and pretty soon we will see the way of all flesh with balloons or the way of all latex, I guess, and we've now popped the balloon and we're headed down toward one of the three trees in Western Oklahoma, and here it comes. And this is my favorite part, where we say, "Ya-ha, we're on the ground."

So come and fly with us and go out there and tell at least one other person why you care.

(Applause)

MR. JACKSON: Thank you very much. In view of our time, I just want to take a few questions if anyone has any questions? Okay, all right, thank you very much, everyone. I think we did have a very exciting panel to look into the future and keep on dreaming. Thank you.

(Applause)

DR. NIELD: Good afternoon, I'm Dr. George Nield, the Deputy Associate Administrator for Commercial Space Transportation, and I have the opportunity to try and wrap up the festivities here this afternoon. Put a ribbon on, put a bow on top, and finish things up. I hope you've enjoyed these presentations and the discussions and the panels at this conference as much as I have.

As I listened to some of those fascinating stories, yesterday, about the early years of AST, it occurred to me that some of you may not really be all that familiar with really who we are and how we spend our time. I'm a relative newcomer in AST. I just arrived at the office 1 year ago this month, but even those of you who were associated with the organization in the old days may not have kept up with some of the many changes that have taken place since that time.

AST's mission is to ensure the protection of the public, property, national security and foreign policy interests of the United States during commercial launch or re-entry activities and to encourage, facilitate, and promote the commercial space transportation industry. We have three divisions in the office, Space Systems Development Division, AST-100; Licensing and Safety Division, AST-200; and the Systems Engineering and Training Division, AST-300.

Each division, of course, has specific responsibilities, but we also make widespread use of teams in our license evaluation and other technical activities. We currently have 59 employees, and we manage to keep fairly busy. There was a question yesterday about where should AST look to find qualified employees to do the kind of work that we're talking about here. Well, we welcome your suggestions on where we should be looking, but let me share with you where we have found the people that we currently have. Our current staff includes people from Boeing, Lockheed Martin, Orbital Sciences Corporation, Fairchild, General Dynamics, Aerojet, Rockwell International, United States Air Force, Naval Air Systems Command, United States Space Alliance, NASA Headquarters, NASA Wallops, NASA Goddard, NASA Langley, NASA Johnson, NASA Kennedy, the White Sands Missile Range, ACTA, Department of Commerce, so a pretty wide group there.

The vast majority of our folks have degrees in aerospace engineering, electrical engineering, mechanical engineering, and related disciplines.

Several have advanced degrees. We have three folks with doctorates. We have several law degrees and some MBAs, but the neat thing is that the folks we have on our team do not just have this academic training. They also have some real world space experience. Some of the programs that our team have worked on before they came to AST and the FAA include Apollo, Skylab, Delta, Atlas, Titan, Pegasus, Scout, Minuteman, Peacekeeper, Minotaur, X-33, X-34, X-38, the Space Shuttle, International Space Station, you get the idea.

We're very proud of our staff, and we think we have a lot to bring to the table when we have a difficult problem to solve or a new policy or regulatory approach that needs development. One thing that we all share is a passion for commercial space, and I hope that shows. We recently compiled a list of some of our accomplishments during FY-2003, and I thought I'd share just a few of those items with you. In 2003 we were very pleased, of course, that all of the FAA licensed launches were completed without injury to the uninvolved public or damage to uninvolved property. We licensed eight commercial launches, including the first launch of the Delta IV, three Atlas launches, three launches by Sea Launch, and a Pegasus XL. We continue to prepare and coordinate common launch safety requirements with our Air Force partners at the ranges.

We developed and published a guide to reusable launch vehicle safety validation and verification planning. We established a commercial space transportation office down at Patrick. AST increased its focus on licensing activities related to the new reusable launch vehicles. We conducted an RLV mission license workshop for potential commercial RLV launch license applicants and related organizations. We received RLV launch license applications from three potential RLV operators and began the evaluation process in order to make timely licensing determinations.

We strengthened our internal training and development program, including developing several new technical training courses. We also released several reports in support of our promotion mission, including the development and concept report and the commercial space transportation forecast. As always, these reports and other AST documents are available on our website.

We issued a notice of intent and held scoping meetings via the web as part of a programmatic environmental impact statement for reusable launch vehicles. We developed draft guidelines for reusable launch vehicle operations and maintenance. We developed and published in the Federal Register definitions for a suborbital rocket and suborbital trajectory. We also continued the development of the Space and Air Traffic Management System. We also conducted a research and development program in support of the FAA's strategic safety goal. Some of our projects included non-traditional flight safety systems, integrated vehicle health management, human space flight safety, thermal protection system inspection and re-entry vehicle hazard model development and calibration.

As we look to the future, we are very excited about what we see for 2004. We expect to conduct several licensed launches for expendable launch vehicles. We anticipate that we will be able to complete the licensing process for one or more suborbital reusable launch vehicles, and we expect to issue a license for a new non-federal spaceport. We also plan to spend time and effort developing guidelines, standards, safety approval processes, and additional regulations if required specifically in areas related to human space flight.

As we work on these new and very challenging tasks we want to sincerely invite your feedback. Please tell us if you have questions, concerns, complaints, or suggestions for how we can do our job better. Whether you prefer to work through the Commercial Space Transportation Advisory Committee, COMSTAC, or contact us directly, we do want to hear from you. These are tough problems we're dealing with, and it is not always immediately obvious as to what is the best approach. We recognize that a regulatory agency is rarely loved or appreciated by the industry that it regulates, but we would hope to earn your trust and respect and that we can work together in a professional and mutually supportive relationship to help ensure a robust and highly successful commercial space transportation industry.

At this point I want to give a special thanks to Doug and Camilla; all of our distinguished speakers, panelists, and panel moderators; all of the behind the scenes workers from AST for making this, the seventh annual conference, one of the best we've ever had. We also appreciate the great facilities and support that we've gotten from the Fairmont. I especially want to thank all of you for your participation and support in this conference this year and certainly look forward to working closely with many of you in the year ahead.

As soon as we are done here, we'll be boarding the buses for the Stephen Udvar-Hazy Center, the huge new Air and Space Museum Annex out at Dulles Airport. If you haven't been there, please consider going. It's really fantastic with the Concorde, the SR-71, the Space Shuttle *Enterprise,* and many other exhibits there, you just won't want to miss it.

Tomorrow, we'll be hosting a special launch site licensing workshop which is really a follow-on to the RLV operator workshop that we held last summer. It will be held in the Bessie Coleman conference room on the second floor of the FAA Headquarters Building from 9:00 o'clock until 2:00 o'clock tomorrow. It should be very informative. It's free, and we'd love to see many of you there, especially those of you here who are associated with some of our prospective new spaceports.

With that, I think we've come to the end of our formal program here. The buses for the museum trip will be leaving at 3:30 from right in front of the hotel. Thank you again for being here today, and we appreciate your participation.

(Applause.)

(Whereupon, at 3:11 p.m. the above entitled matter concluded.)